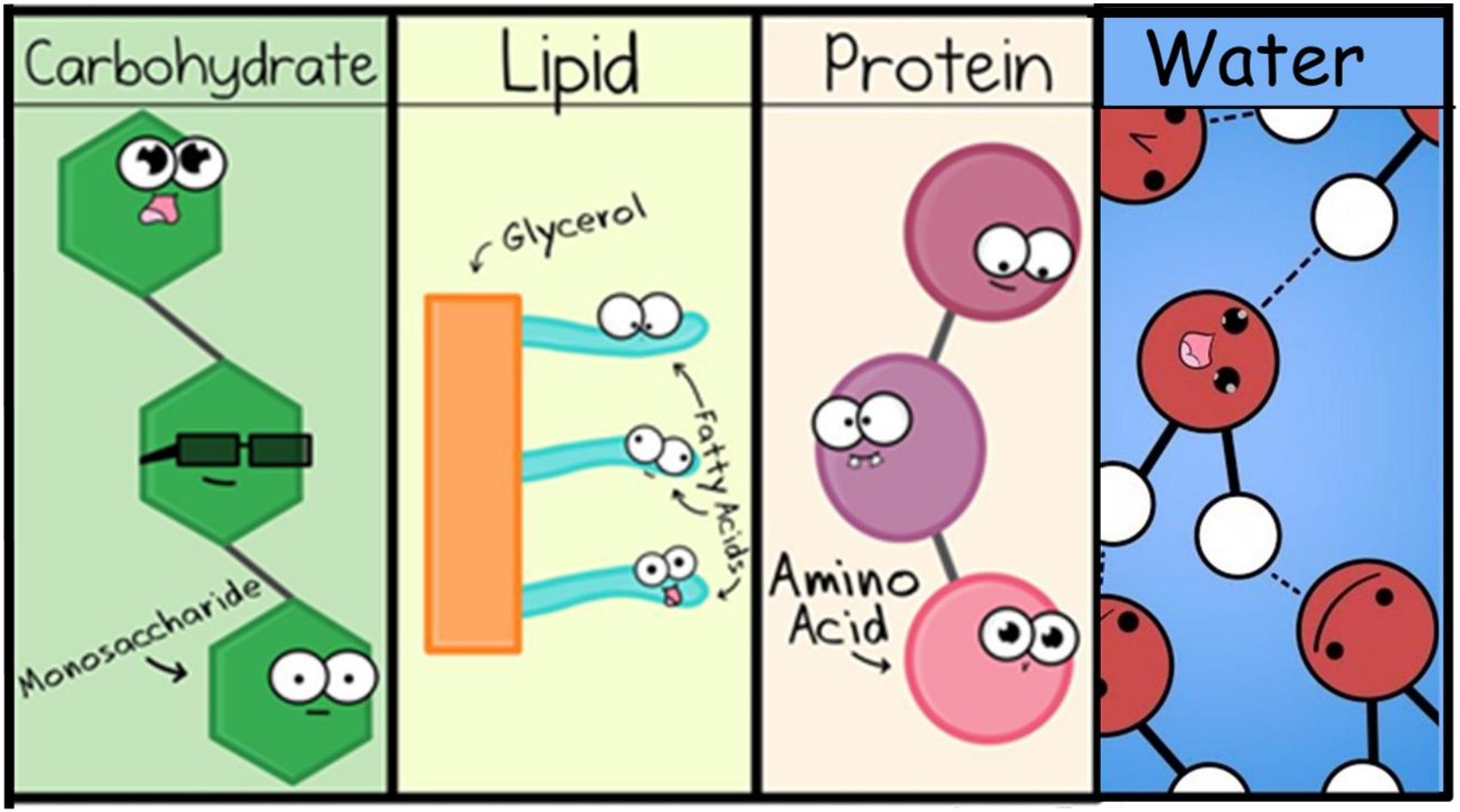
Cambridge Assessment International Education

AS Level

Chapter 2

Biological Molecules



Chapter Outline

Monomer to Polymer
Hydrolysis and Condensation

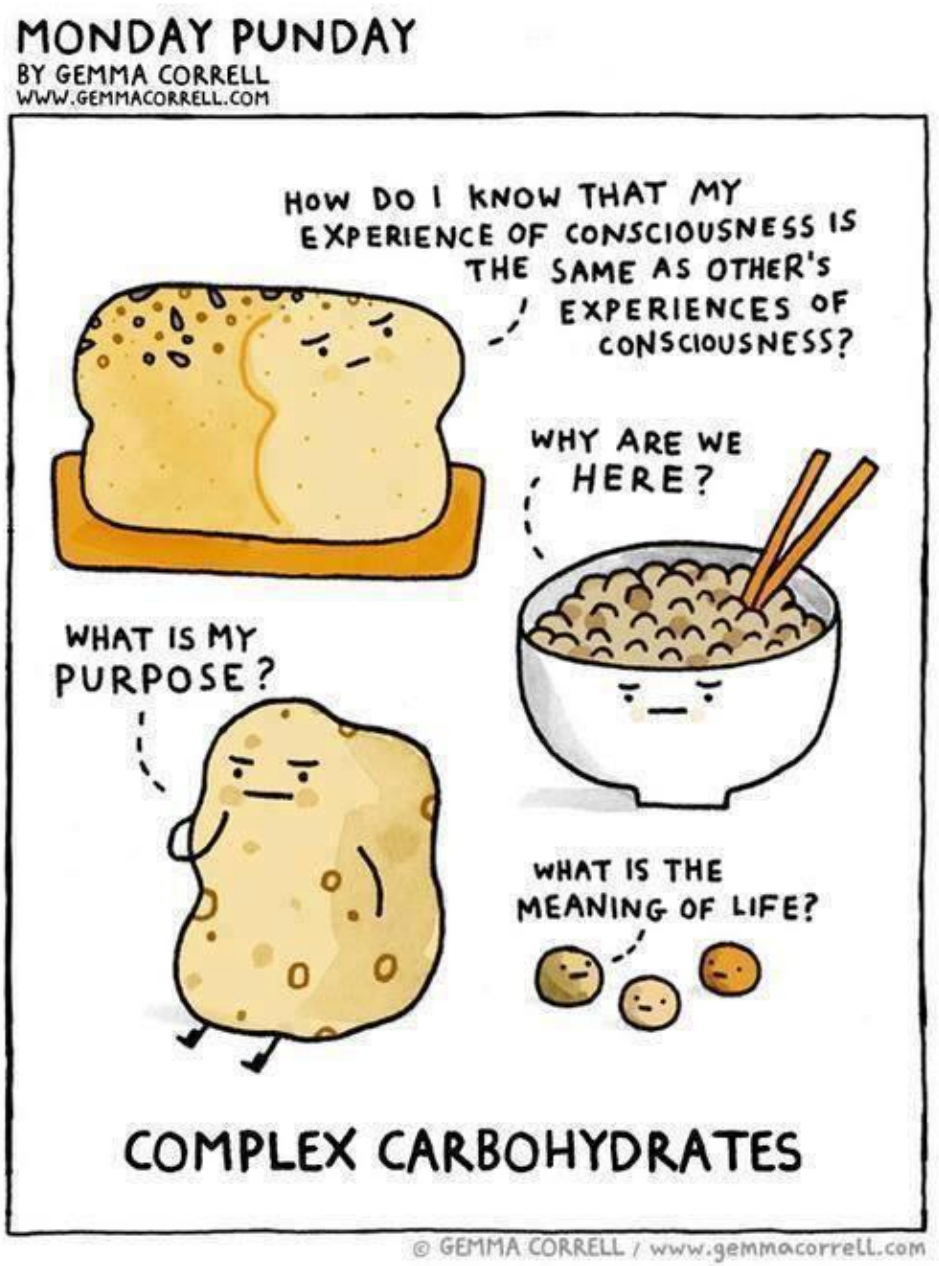
Carbohydrates
- Monosaccharide, disaccharide and polysaccharide
- Glycosidic bond
- Starch (amylose and amylopectin)
- Glycogen
- Cellulose
- Benedict's Test / Iodine Test

Lipids
- Glycerol + 3 Fatty acids
- Ester bond
- Triglycerides
- Phospholipids
- Emulsion Test

Protein
- Amino acids
- Peptide bond
- Primary to quaternary structure
- Globular vs Fibrous proteins
- Haemoglobin
- Collagen
- Biuret Test

Water
- Hydrogen bond

Carbohydrates


MONDAY PUNDAY
BY GEMMA CORRELL
WWW.GEMMACORRELL.COM
HOW DO I KNOW THAT MY EXPERIENCE OF CONSCIOUSNESS IS THE SAME AS OTHER'S EXPERIENCES OF CONSCIOUSNESS?
WHY ARE WE HERE?
WHAT IS MY PURPOSE?
WHAT IS THE MEANING OF LIFE?
COMPLEX CARBOHYDRATES
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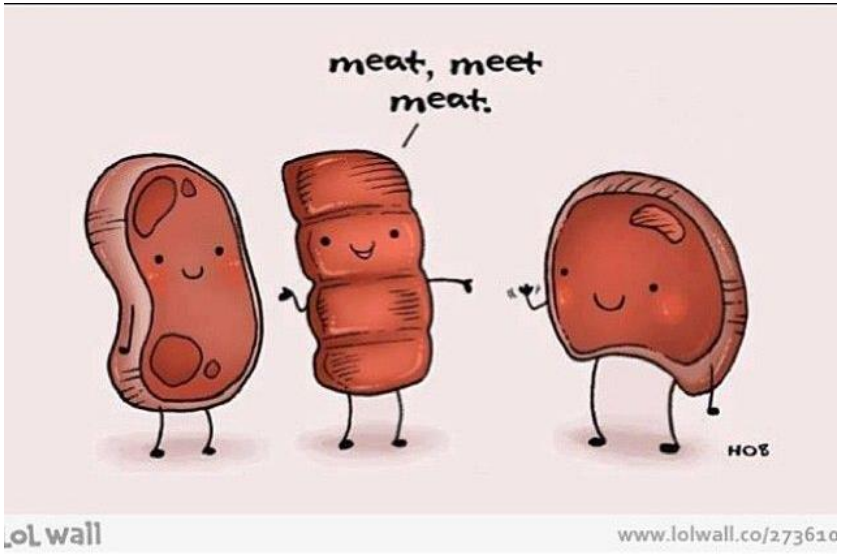
Proteins



Lipids

The Building Blocks of Life

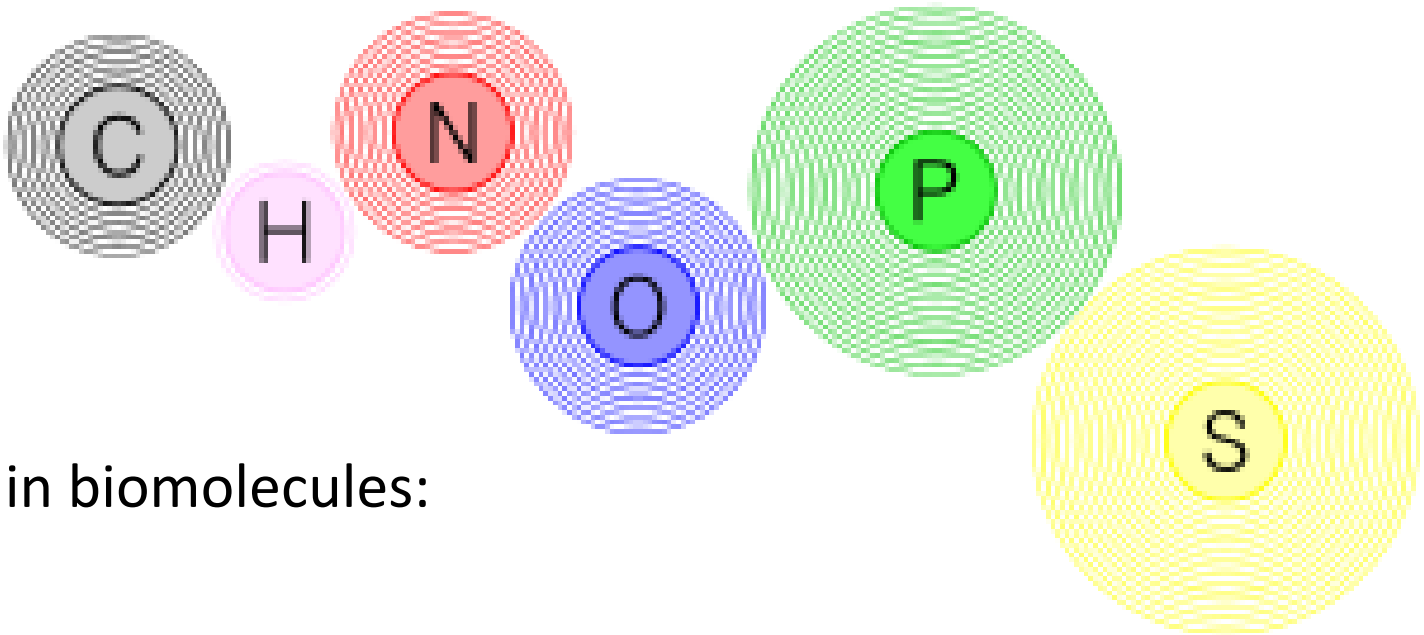
4 most common elements in living organisms:

Carbon

Hydrogen

Oxygen

Nitrogen



Also common in biomolecules:

Phosphorus

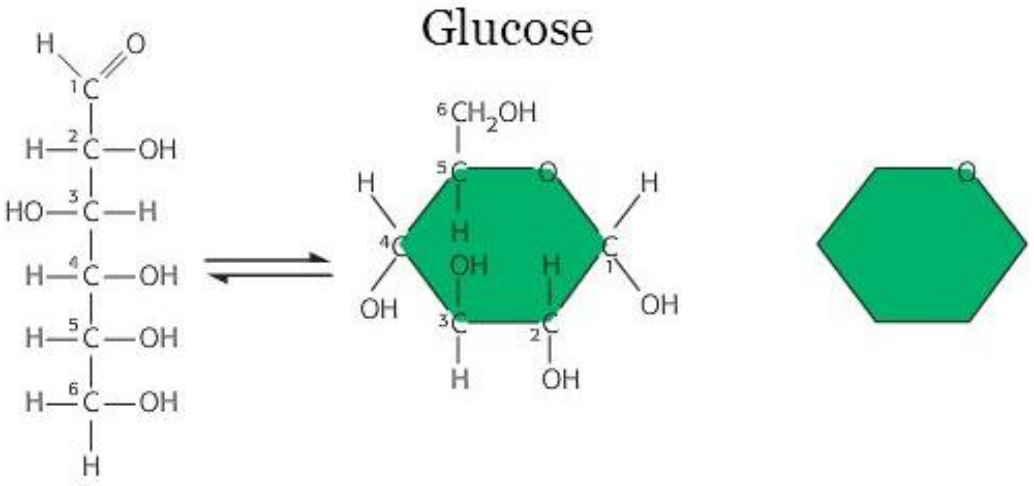
Sulpur

Monomers

- Elements make up **monomers**
- **Simplest repeating unit of a polymer**

E.g. of monomers:

- Monosaccharides (carbohydrate monomers)
- Amino acids
- Nucleotides
- Fatty acids, Glycerol



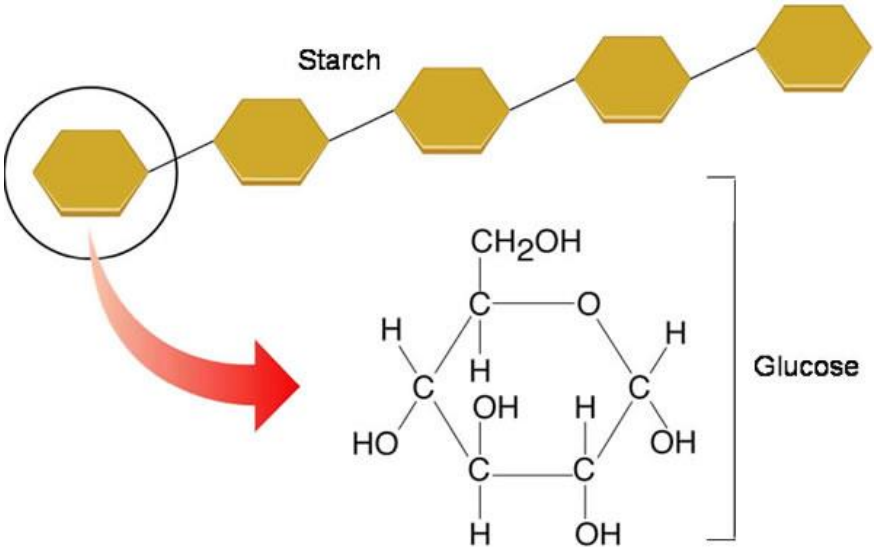
Polymers

- Polymers are made of

1) **Repeating monomers**

2) Joined **end to end**

→ In a process called **polymerisation**



E.g. of polymers:

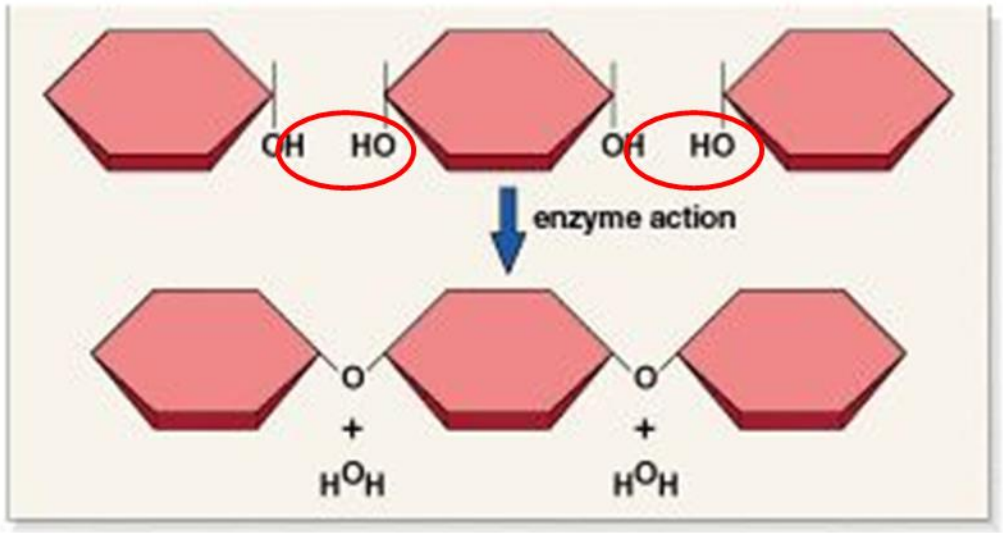
- Polysaccharides – carbohydrates
- Polypeptides – protein
- Polynucleotides – nucleic acids

- Polymers can become so large in size → **macromolecule**
- **Giant** molecule

Condensation and Hydrolysis

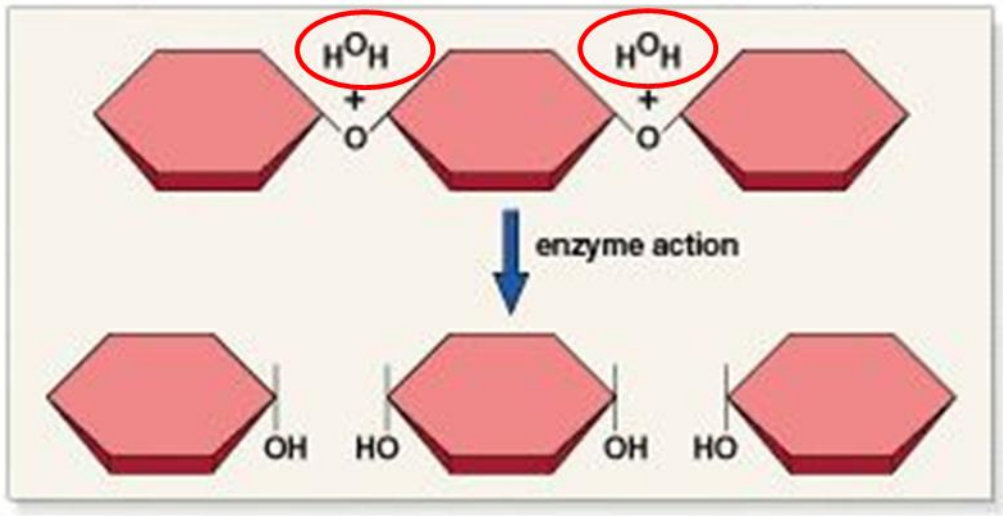
Condensation:

- Two molecules combine
- Removal of water



Hydrolysis:

- Molecule breaks down
- Addition of water



CARBOHYDRATES

Updated on 25/8/21 by Beh SJ @behlogy

Carbohydrates

- Made of **C, H, O**
- General formula: $C_x(H_20)_y$

3 groups:

1) Monosaccharides

2) Disaccharides

3) Polysaccharides

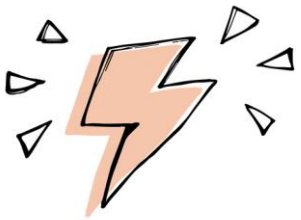
Carbohydrates

Roles of Carbohydrates in Living Organisms

1) Source of energy in respiration

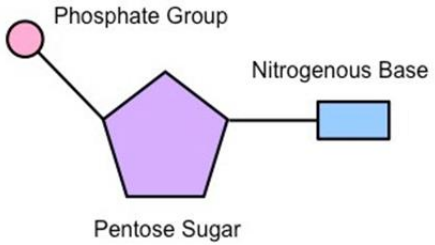
Eg: Starch, glycogen

High C-H bonds→ energy → ATP



2) Building blocks for larger molecules

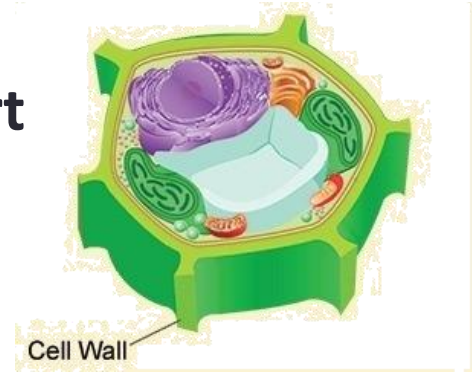
Eg: RNA, DNA, ATP, glycoproteins and glycolipids in plasma membranes



Nucleotide

3) Structural support

Eg: Cellulose



Carbohydrates

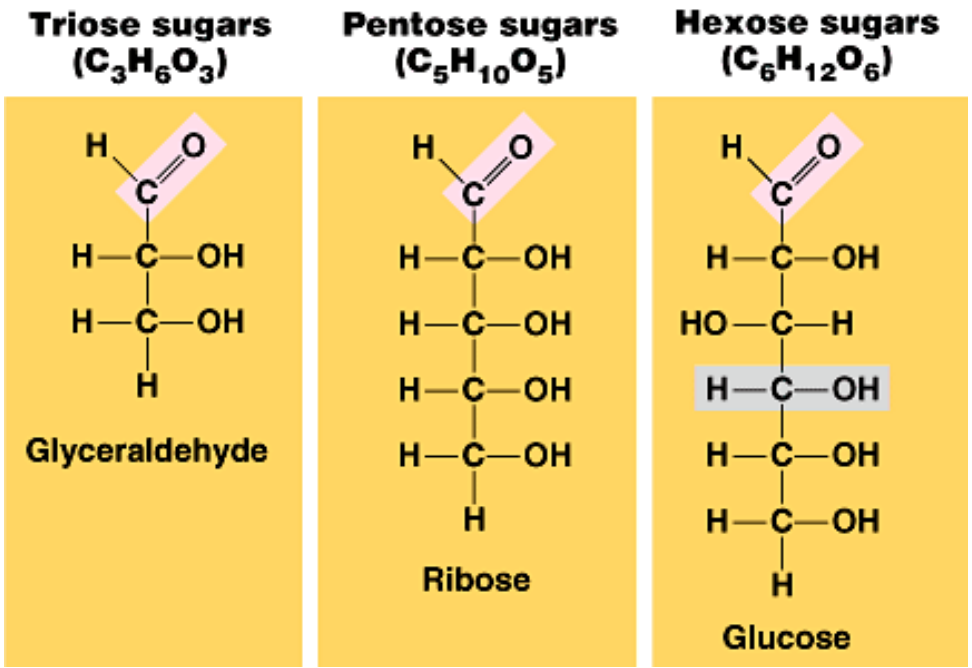
Monosaccharides

- Single sugar molecule
- **Soluble, sweet**
- Molecular formula: **$C_nH_{2n}O_n$**

Classified according to the number of carbon atoms:

- 3C – triose ($C_3H_6O_3$)
- 5C – pentose ($C_5H_{10}O_5$)
- 6C – hexose (**$C_6H_{12}O_6$**)

Structural formula



Carbohydrates

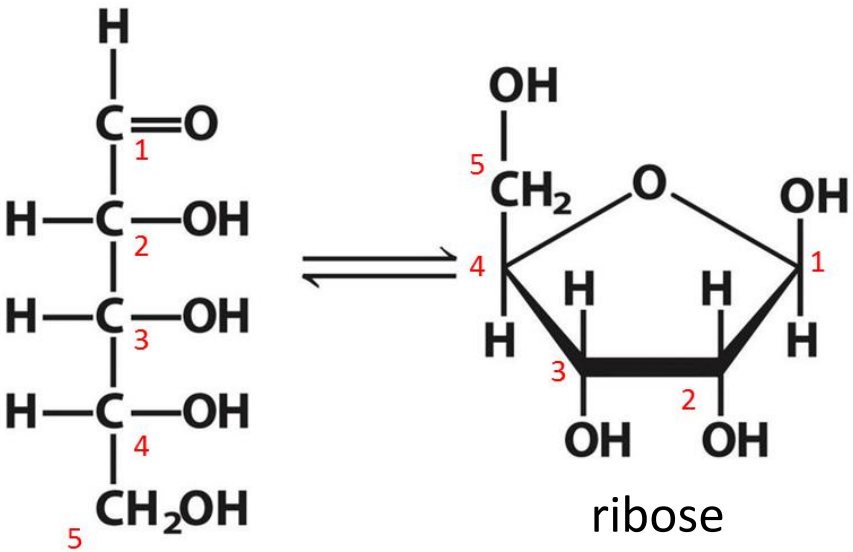
Linear Structures vs Ring Structures

- In pentose and hexose sugars (5C and 6C)

→ Chain of carbon atoms are long enough to close up on itself

→ **Ring structure**

→ **More stable**, more common



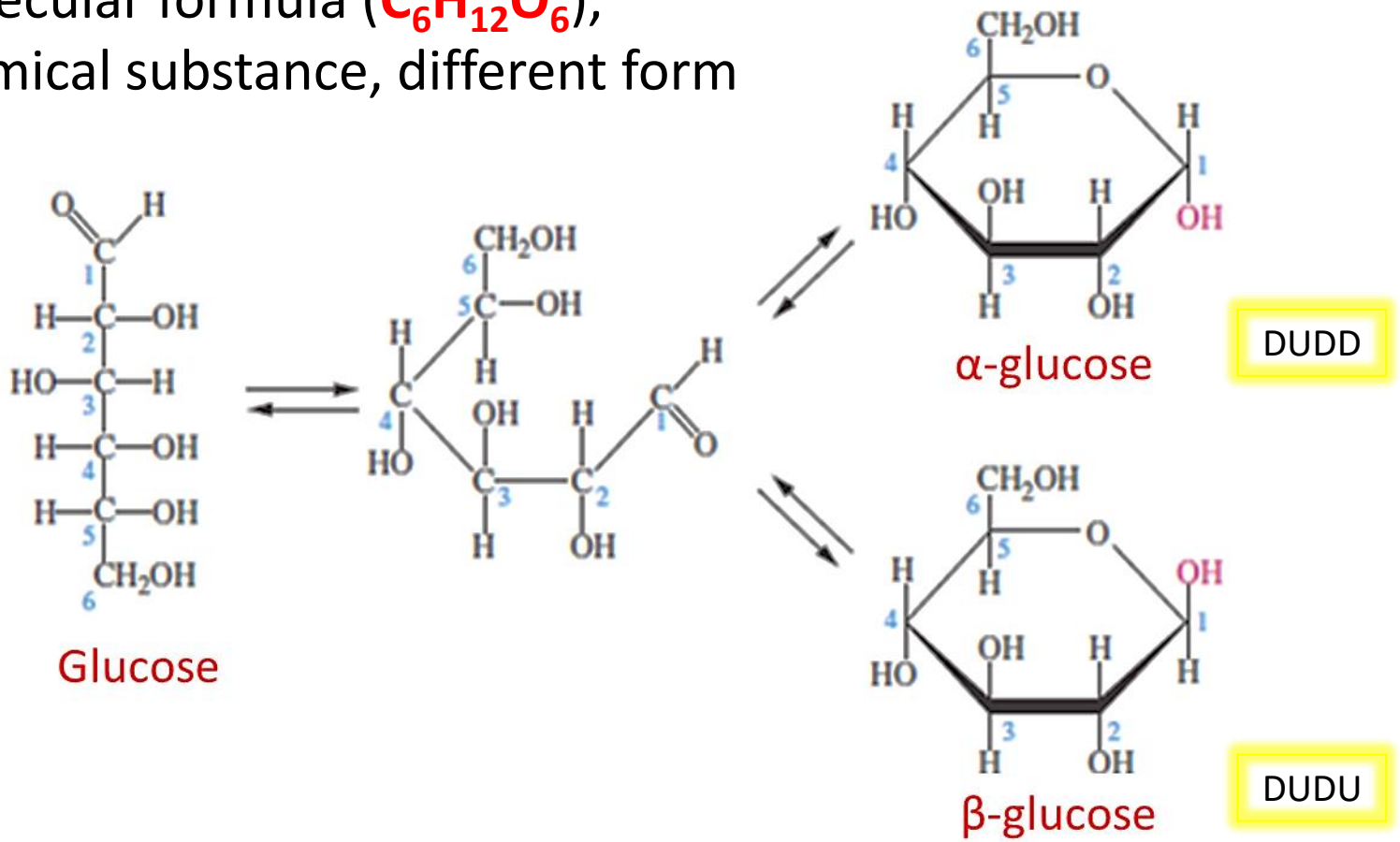
ribose

Carbohydrates

Ring Structures of Glucose

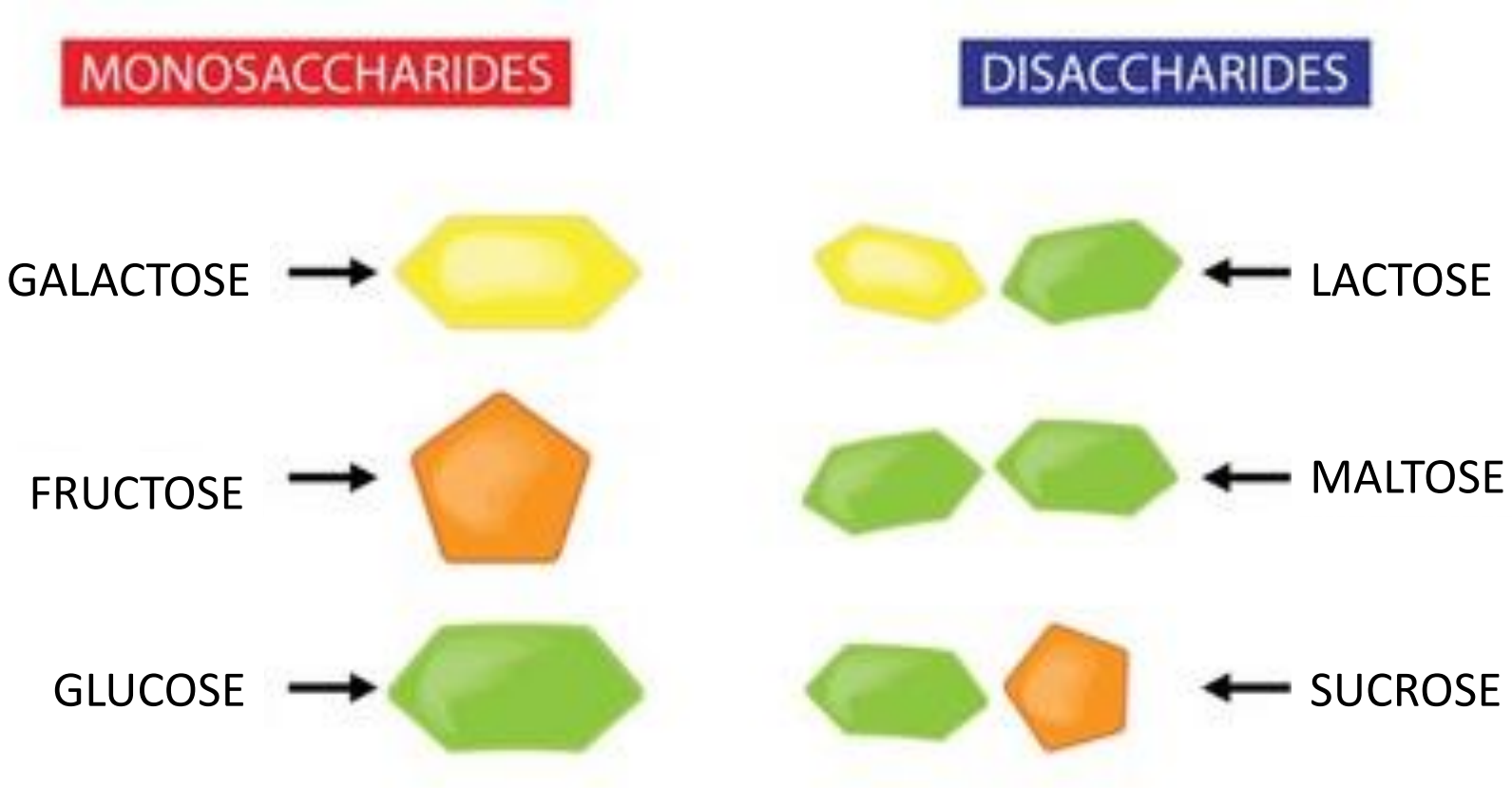
- Close up at C1 and C5
- Has 2 isomers: **α- glucose** and **β-glucose**
- Same molecular formula (**$C_6H_{12}O_6$**), same chemical substance, different form

You need to remember how to draw the ring structure of **α- glucose and β-glucose!**



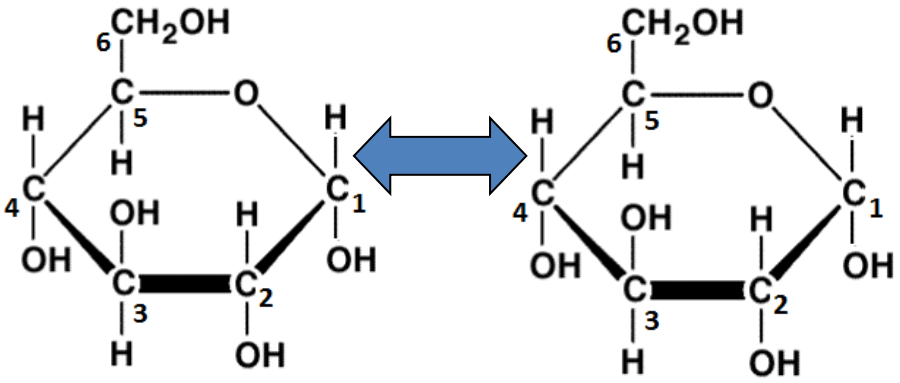
Carbohydrates

Disaccharides



Carbohydrates

Disaccharides



- Soluble, sweet
- Formed from 2 monosaccharides
- Through a process called **condensation**
- 1 hydroxyl group (-OH) + hydrogen atom (H)

→ **Produce 1 water molecule** (H_2O)

- **Glycosidic bond** formed – this is a covalent bond

- Break down of disaccharides to monosaccharides

→ **Hydrolysis**

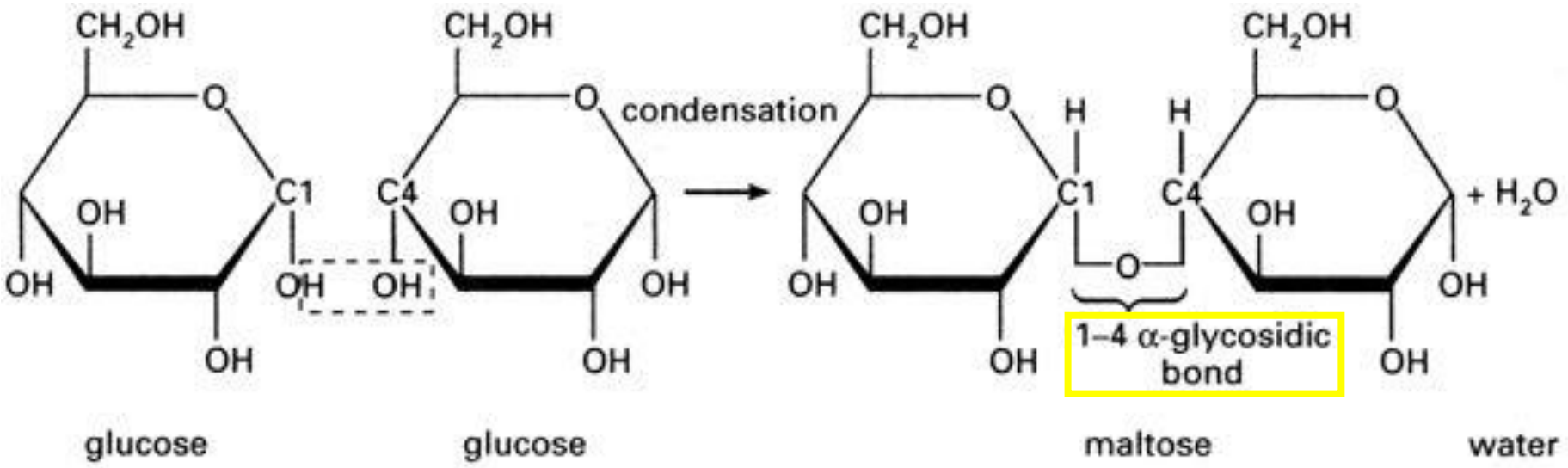
→ **Require addition of water**

- Both reactions controlled by enzymes

Formation of Disaccharide - Maltose

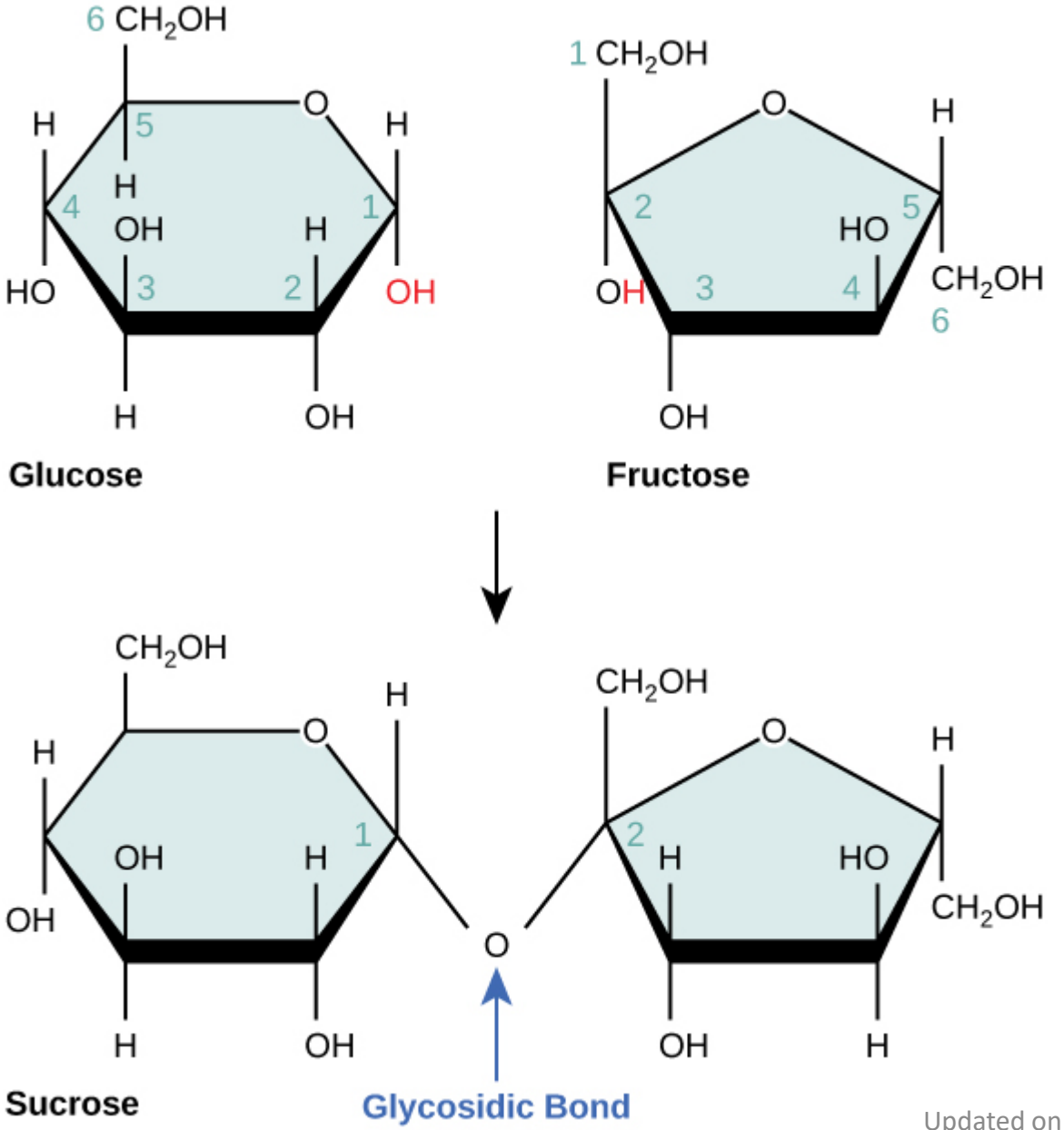
1 ring

2 rings
"oxygen bridge"

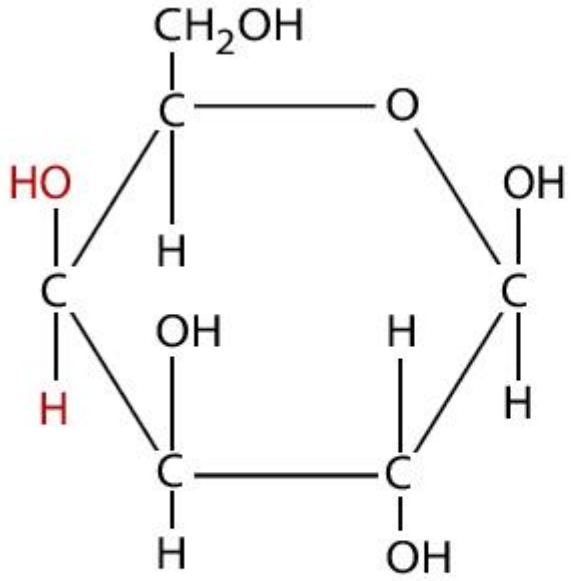


You need to know how to draw products of condensation / hydrolysis reactions!

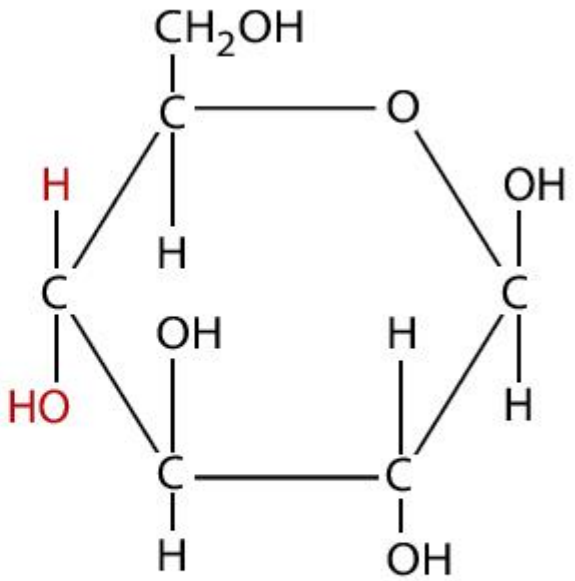
Formation of Disaccharide - Sucrose



Formation of Disaccharide - Lactose



Galactose



Glucose

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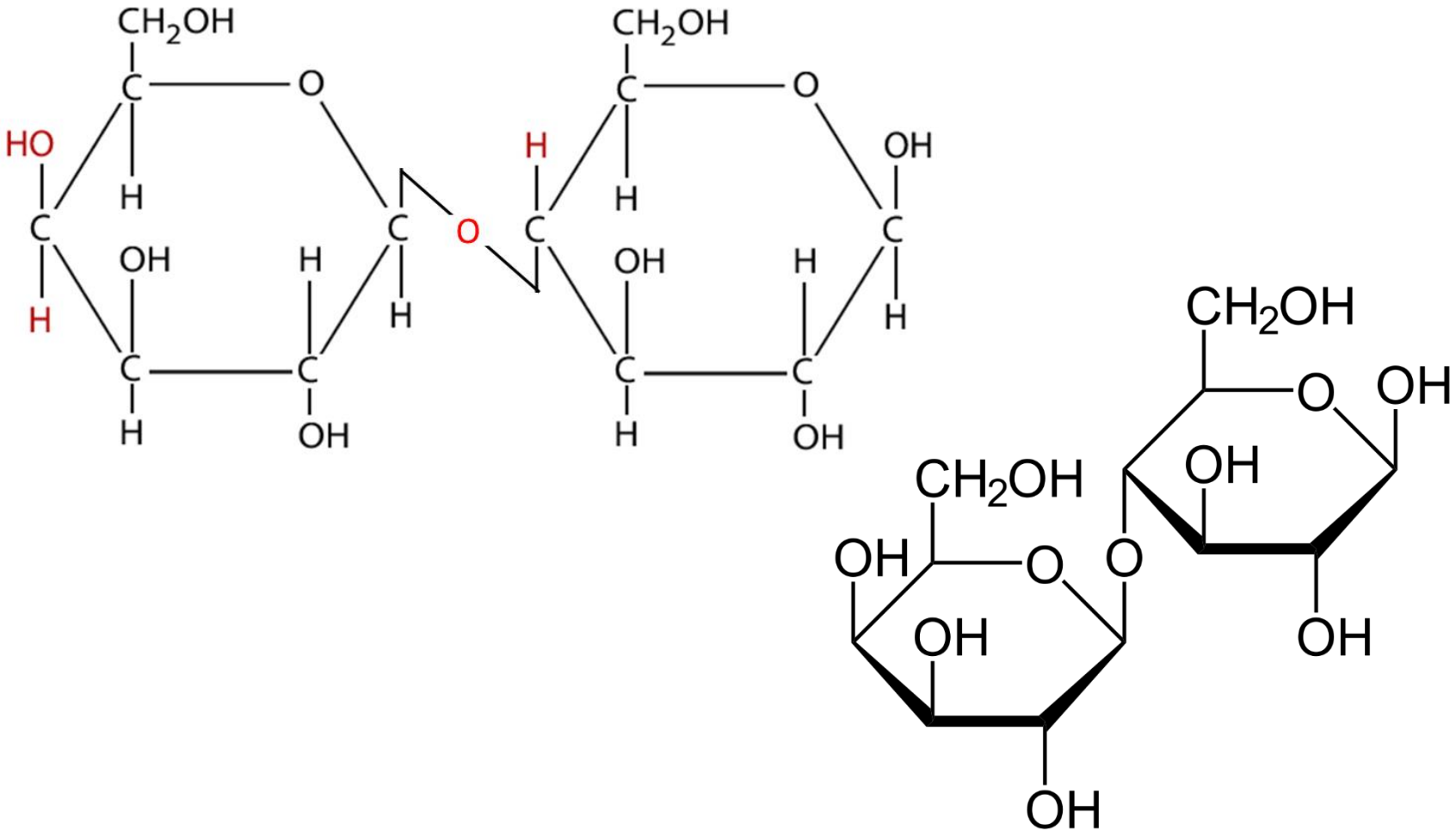
- Draw the structural formula of lactose.

Formation of Disaccharide - Lactose

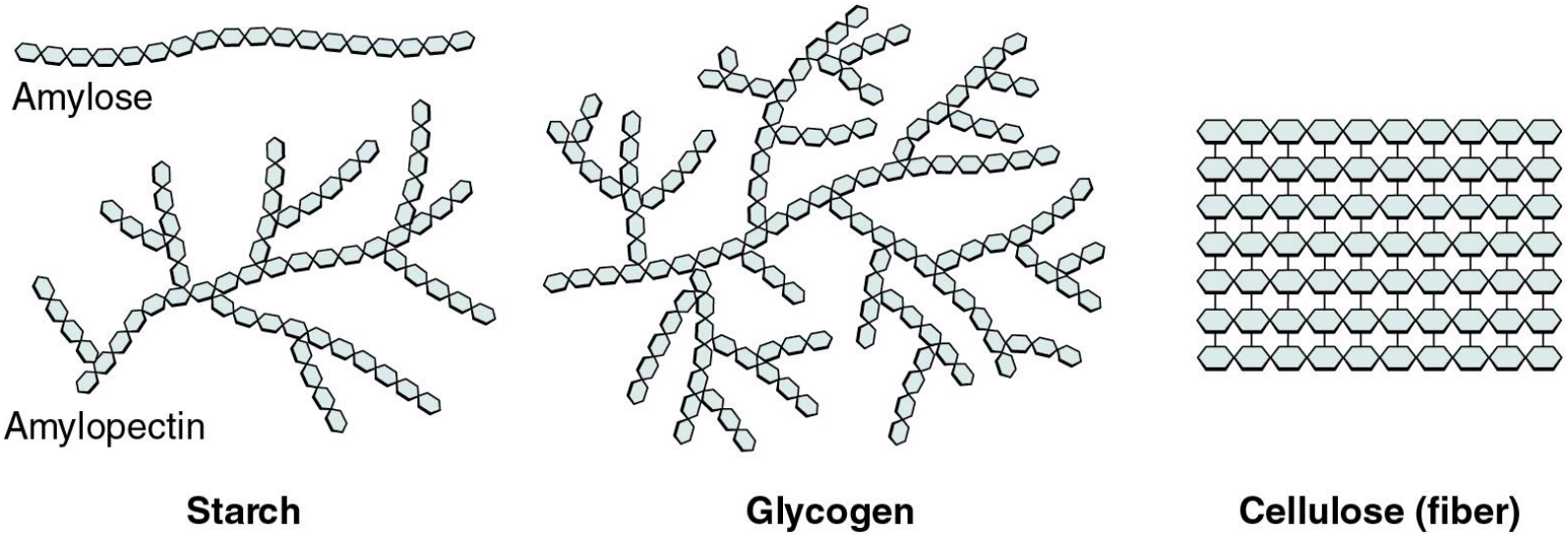


Carbohydrates

Polysaccharides

- Polymers / macromolecules
- Made via **condensation**
- **Glycosidic bonds**

- Not sugars → **not sweet, insoluble**
- E.g. **Starch**, **glycogen**, **cellulose**



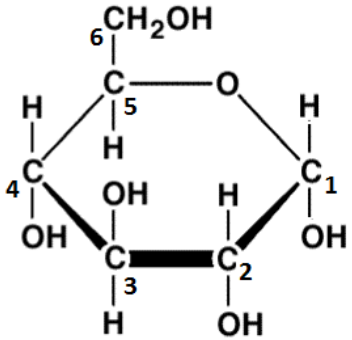
Carbohydrates

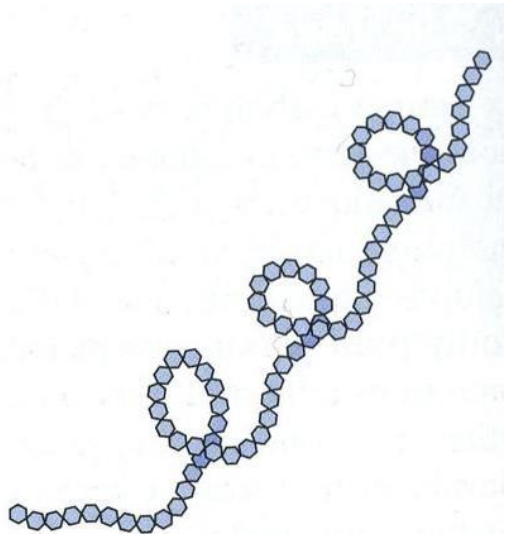
Polysaccharides - Starch

- Storage molecule in **plants**
- Food reserve
- Amylose + amylopectin

1) Amylose

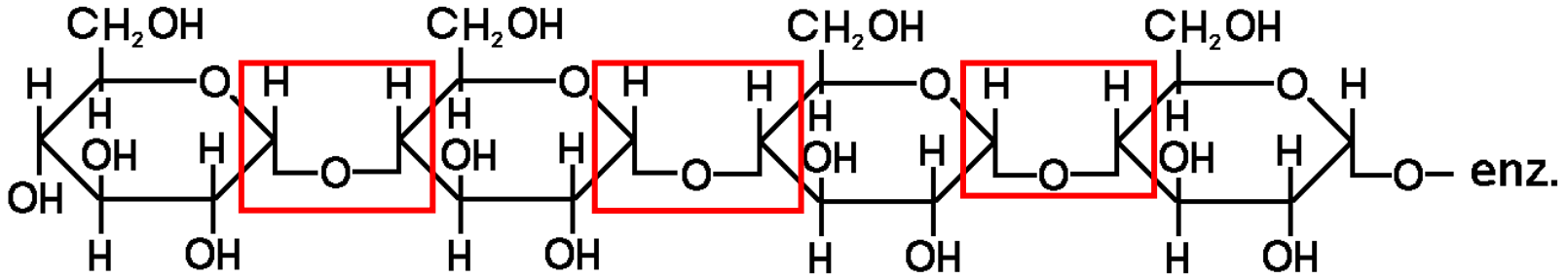
- Made from **α-glucose** molecules
- Linked by 1-4 glycosidic bonds
- Long, **helical**
- **Unbranched**, linear chain



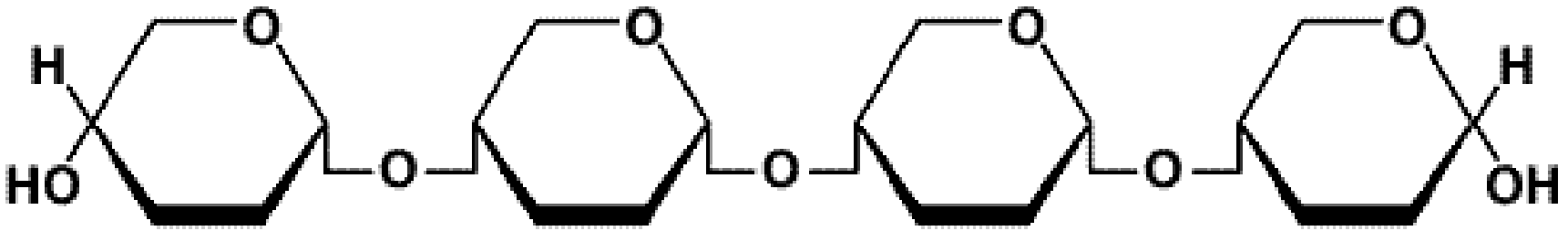


Carbohydrates

Polysaccharides - Starch



1-4 linkages



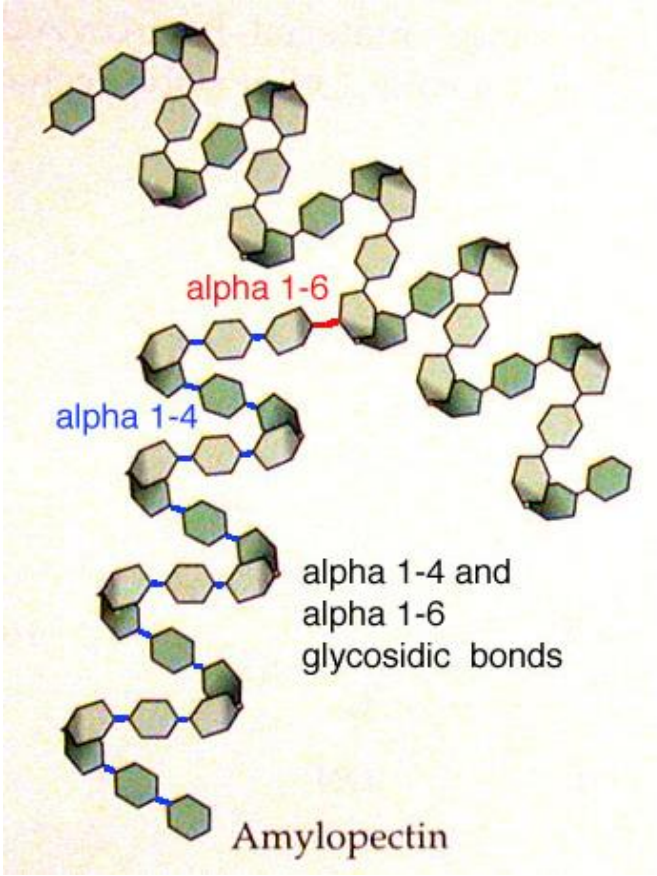
Amylose

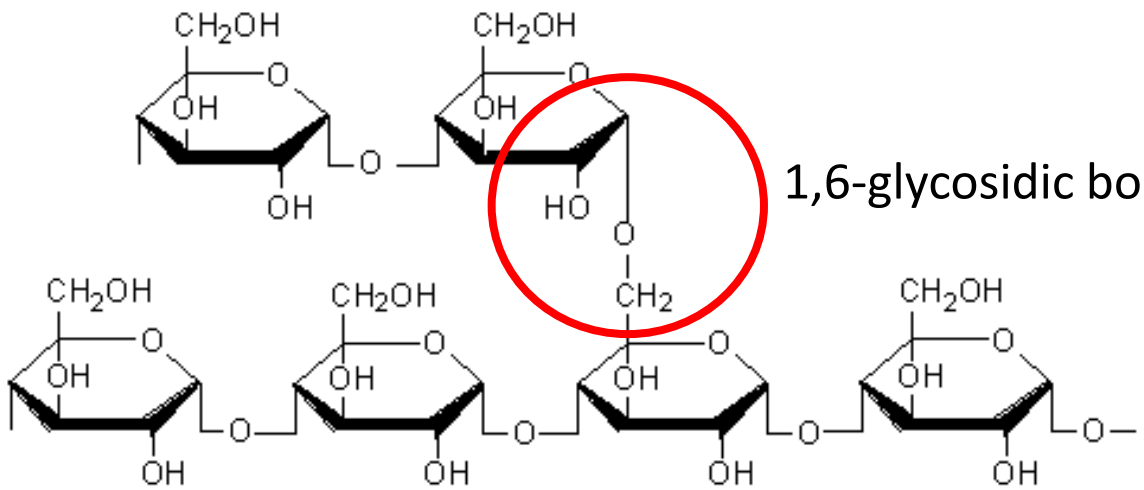
Carbohydrates

Polysaccharides - Starch

2) Amylopectin

- **Branched** molecule
- Made of α-glucose molecules
- **1-4 and 1-6 glycosidic bonds**
- **Branches are at 1-6 linkages**
- Shorter chains

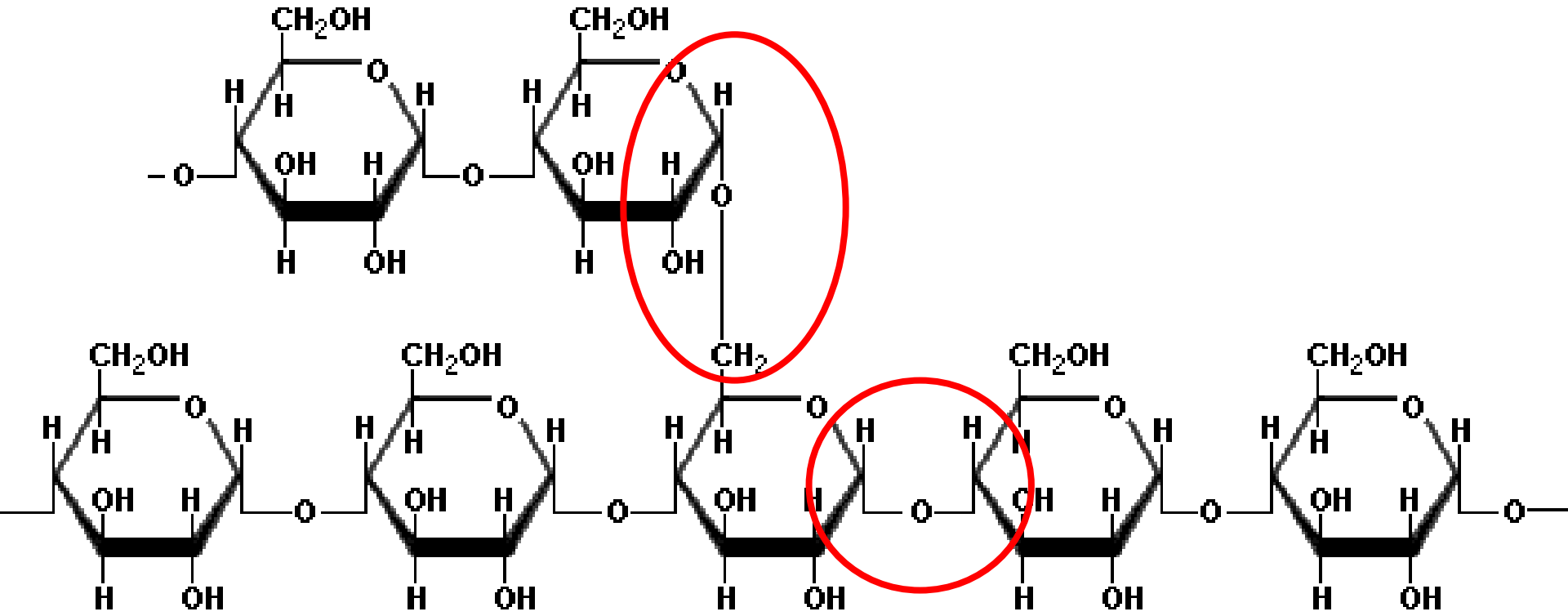




Carbohydrates

Polysaccharides - Starch

Amylopectin



Testing the Presence of Starch

- **Iodine *solution***
- Iodine in potassium iodide solution

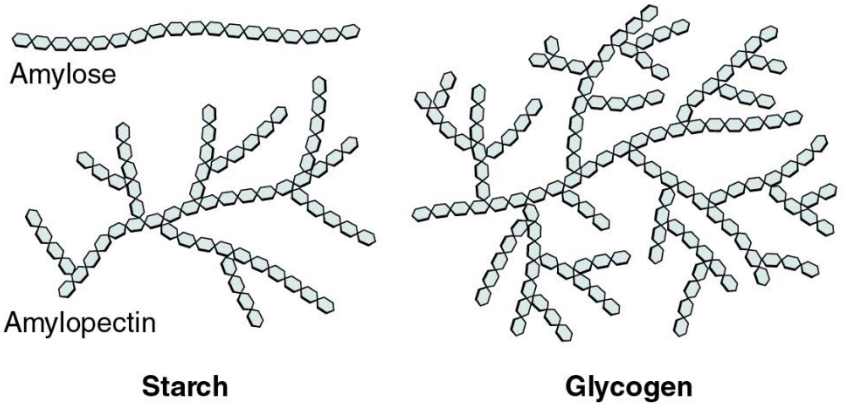
- Reacts with amylose in starch
- Form a starch-iodine complex

- Orange / brown → Dark blue

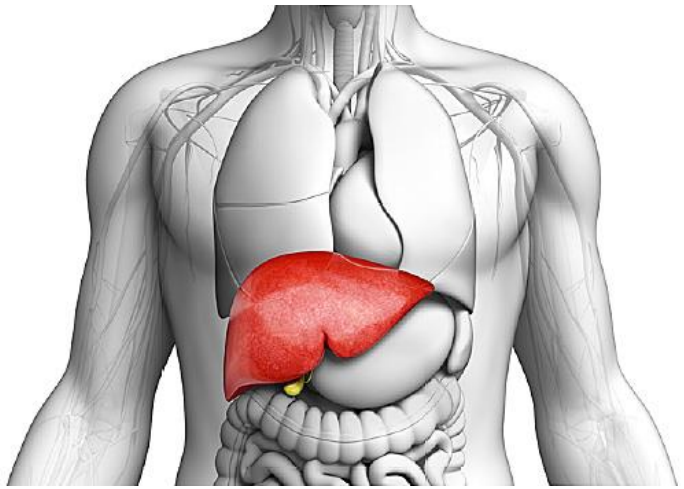
Carbohydrates

Polysaccharides - Glycogen

- Storage of carbohydrates in **animals**
- Structure similar to amylopectin

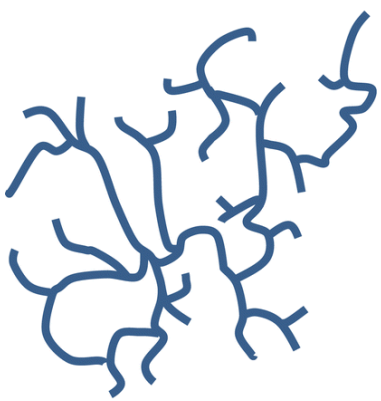


- **α-glucose**
- **1-4 and 1-6 glycosidic bonds**
- **More branched** than amylopectin
- Clumped together → forms granules
- Abundant in **liver and muscle cells**

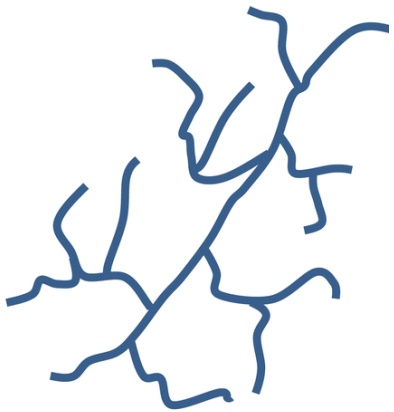


Carbohydrates

Polysaccharides - Glycogen

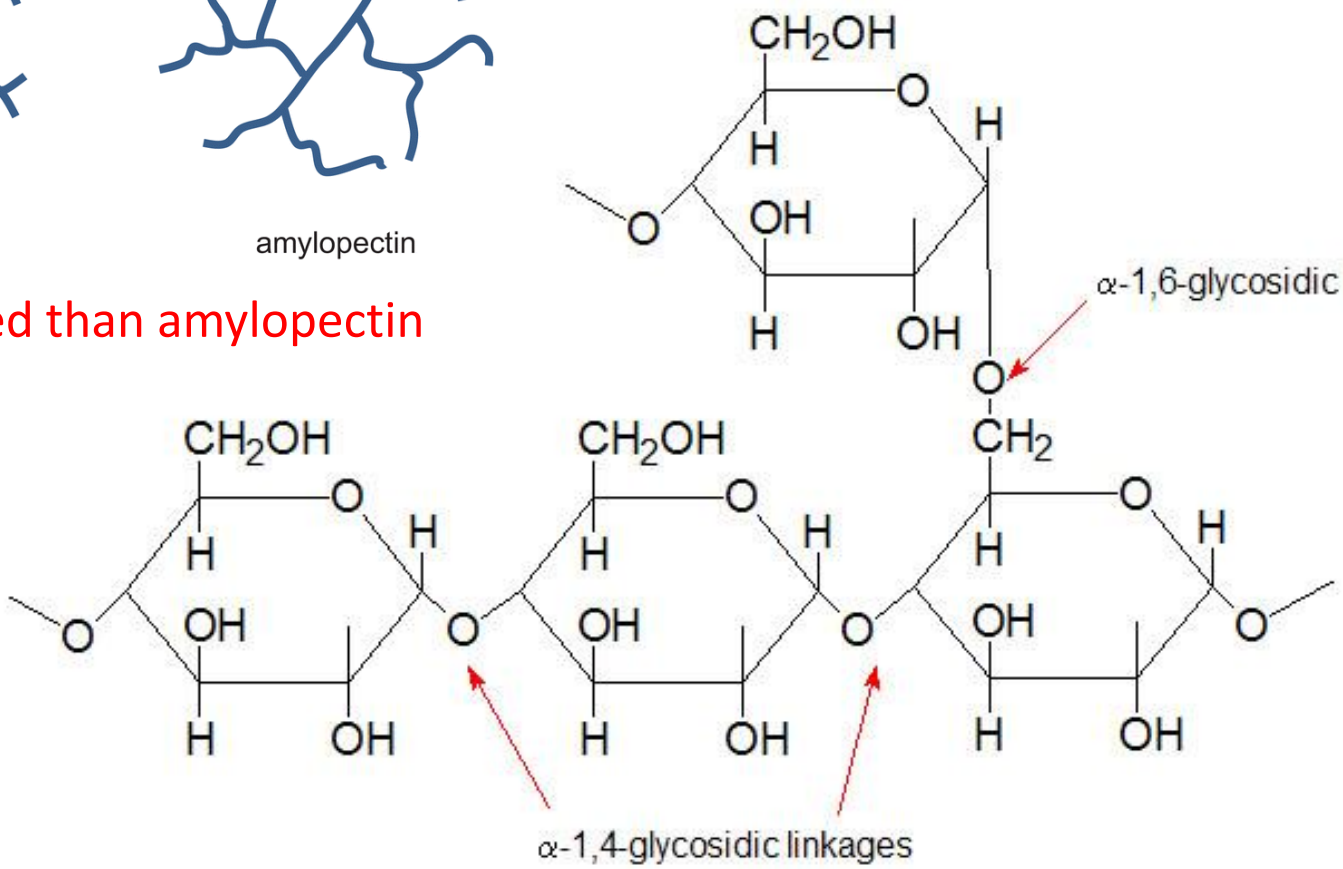


glycogen



amylopectin

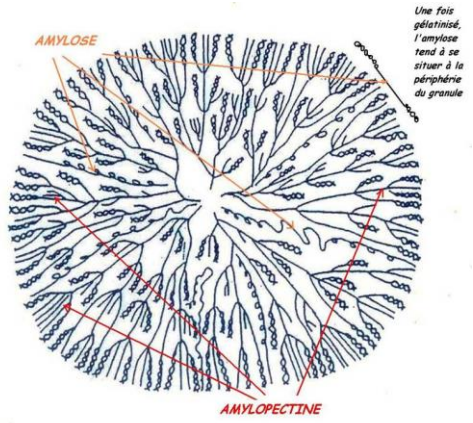
More branched than amylopectin



Q: Why does excess glucose need to be stored as starch and glycogen?

Glucose is:

- **Soluble** – increase concentration / decrease water potential of cell → water would enter → cell volume increase, animal cells may burst
- **Reactive** – interferes with other reactions in cell

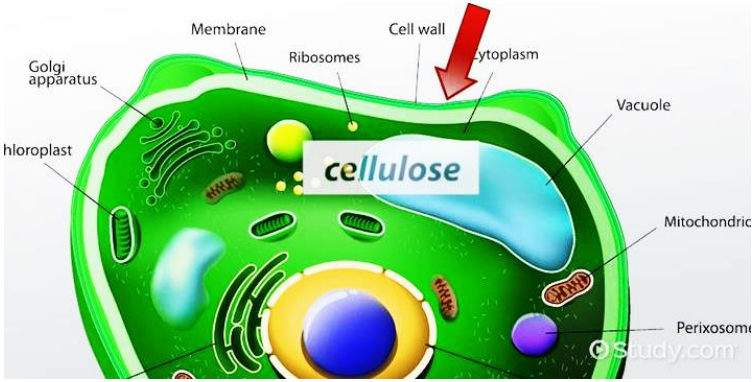


Starch and glycogen is:

- **Inert** – non reactive
- **Insoluble** – no osmotic effect on cell, does not easily diffuse out of cell
- **Compact** – large quantity of energy released when hydrolysed
- **Glucose can be stored / mobilised quickly** – many ends for attachment/removal of glucose

Carbohydrates

Polysaccharides - Cellulose



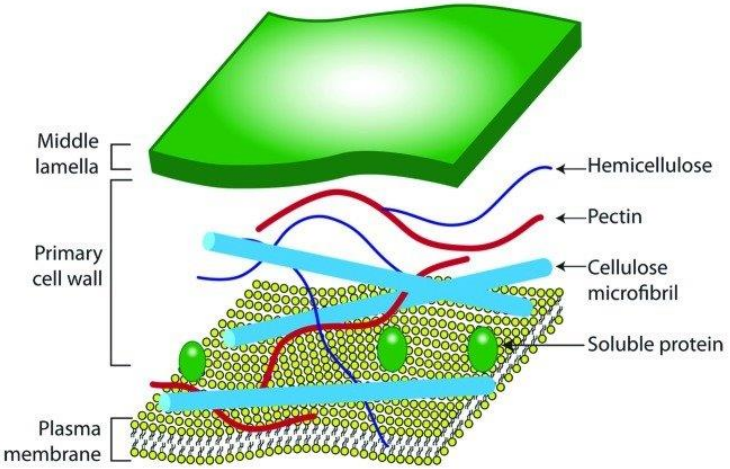
- Structural role in **plant cell walls**

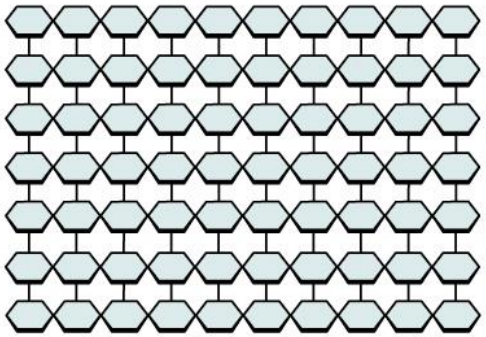
→ **High tensile strength**

→ Prevent cell bursting

→ Helps cell withstand turgor pressure

→ Fully permeable

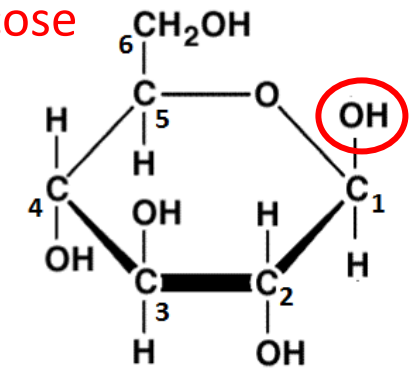




Carbohydrates

Polysaccharides - Cellulose

β-glucose

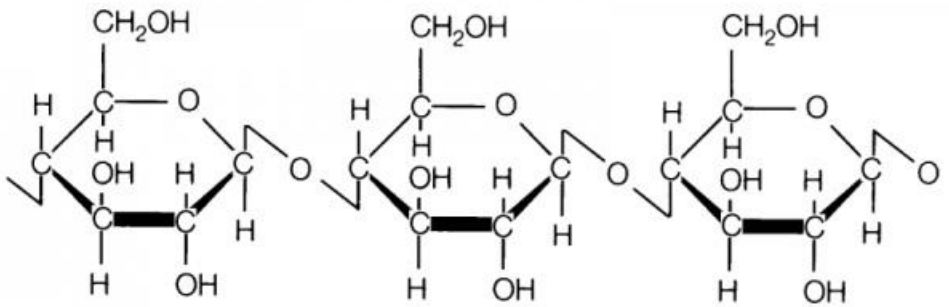


Structure:

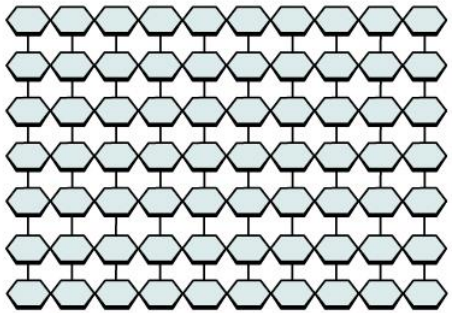
- **β-glucose**

→ Molecules of β-glucose are **rotated at 180°** to each another

→ **1-4 glycosidic bonds**



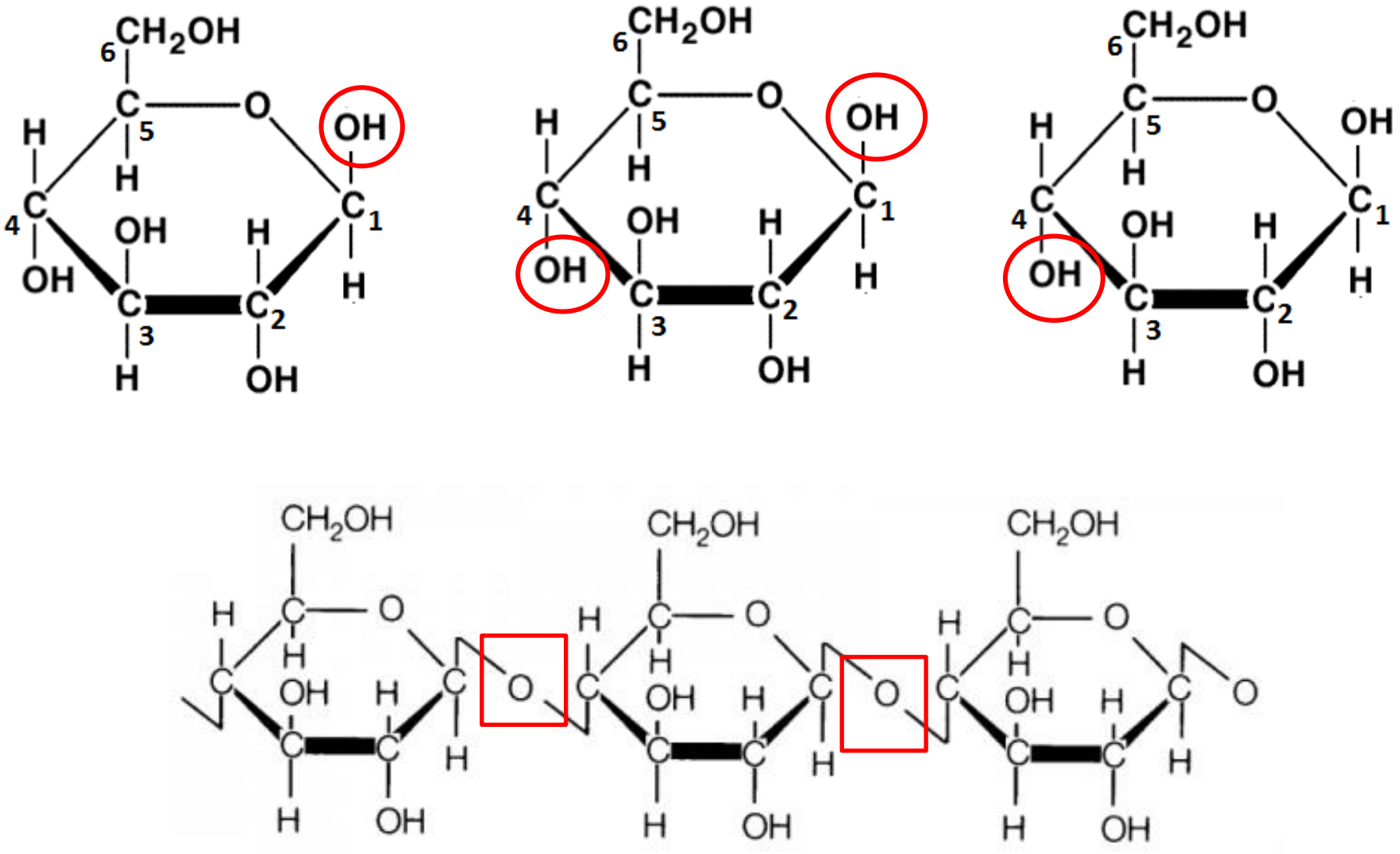
- **Unbranched**, straight chain, linear



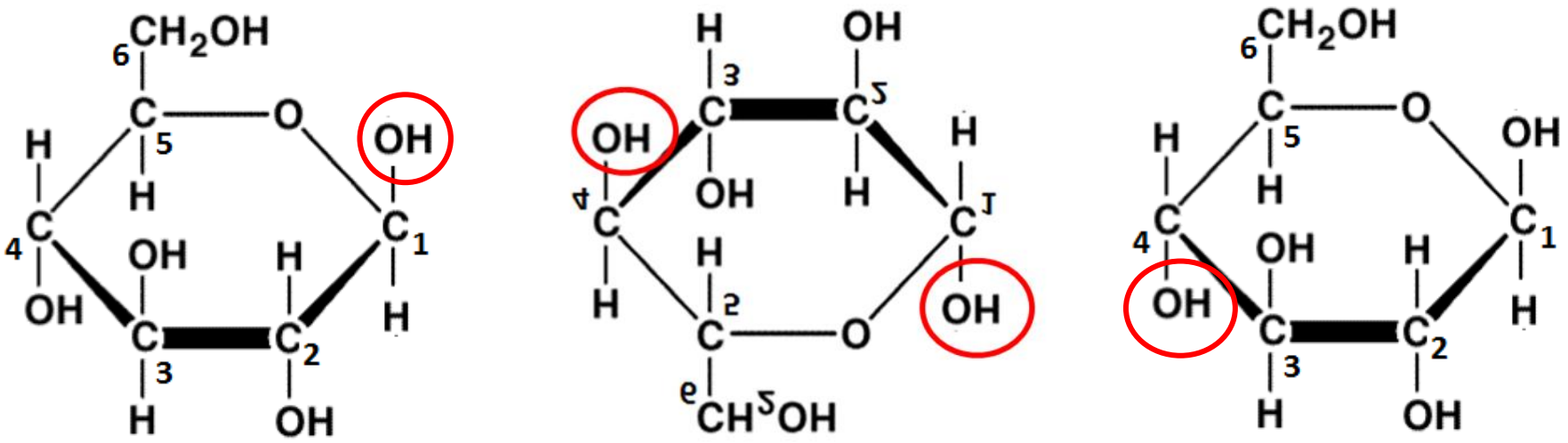
→ Form **fibres**

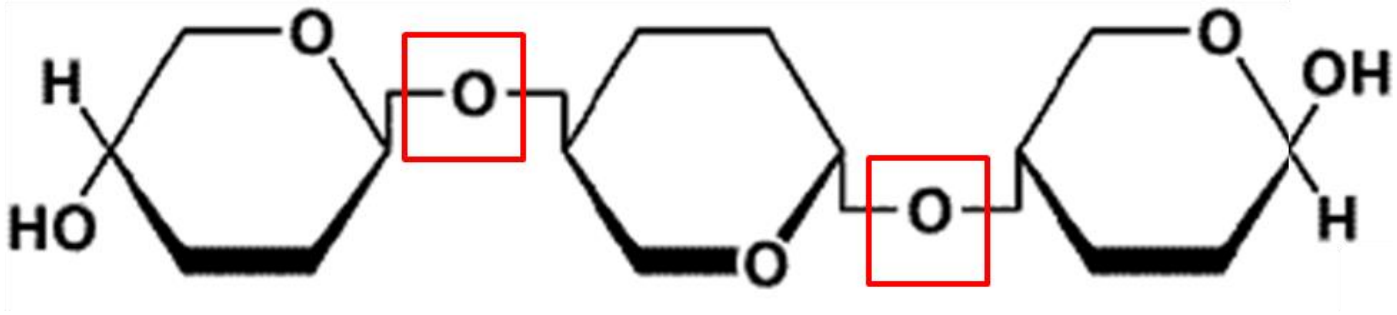
Cellulose (fiber)

Condensation of β-glucose into cellulose



Condensation of β-glucose into cellulose





β, 1-4 glycosidic bonds

Carbohydrates

Polysaccharides - Cellulose

From molecules → fibres with high tensile strength:

Beta-glucose → Cellulose molecule → Microfibril → Fibre

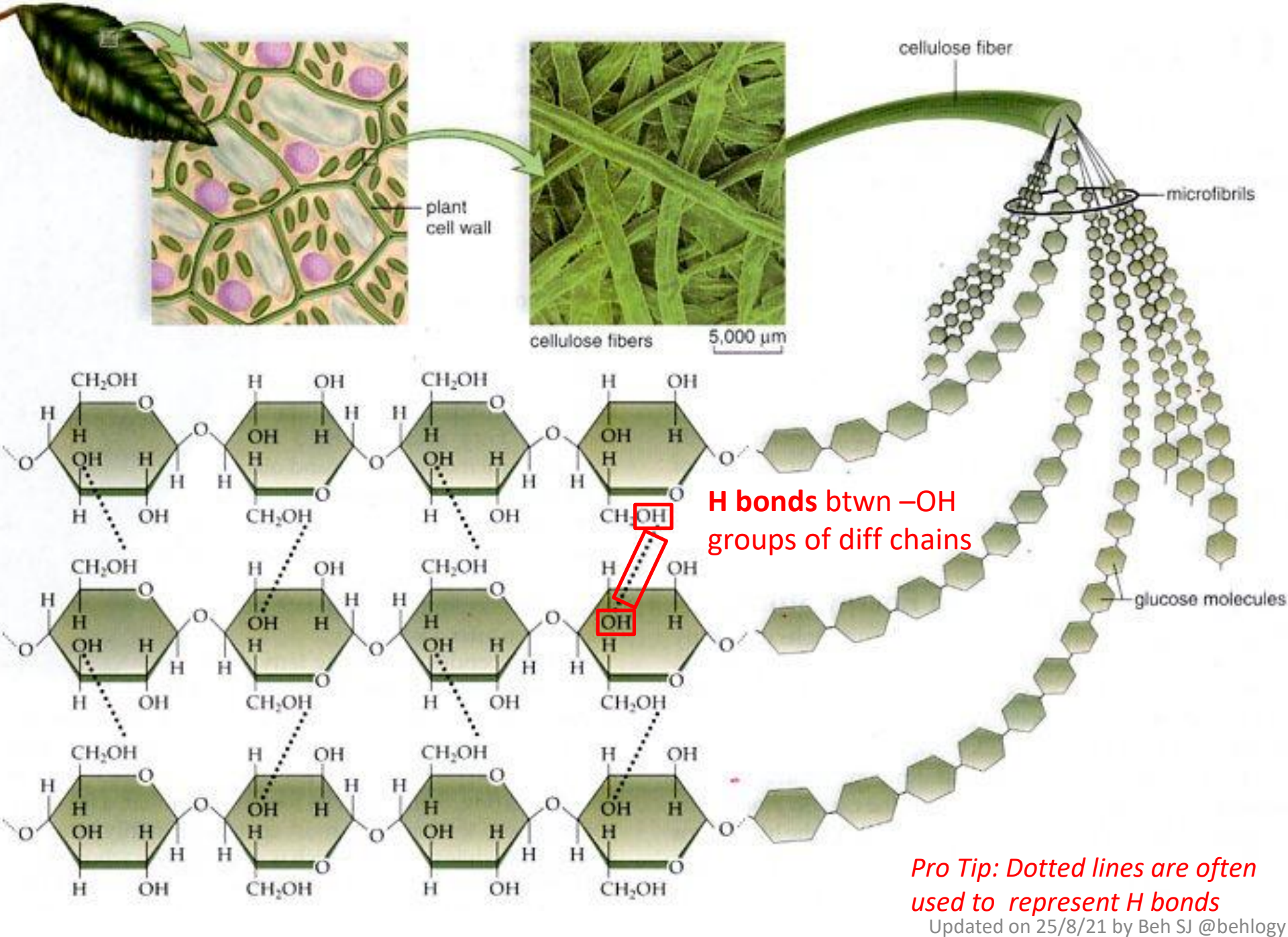
1) Cellulose are straight chains, can **lie parallel** to each other

2) **Hydrogens bonds** formed **between** cellulose molecules
→ many –OH groups in cellulose

3) **Forms microfibrils and fibres**

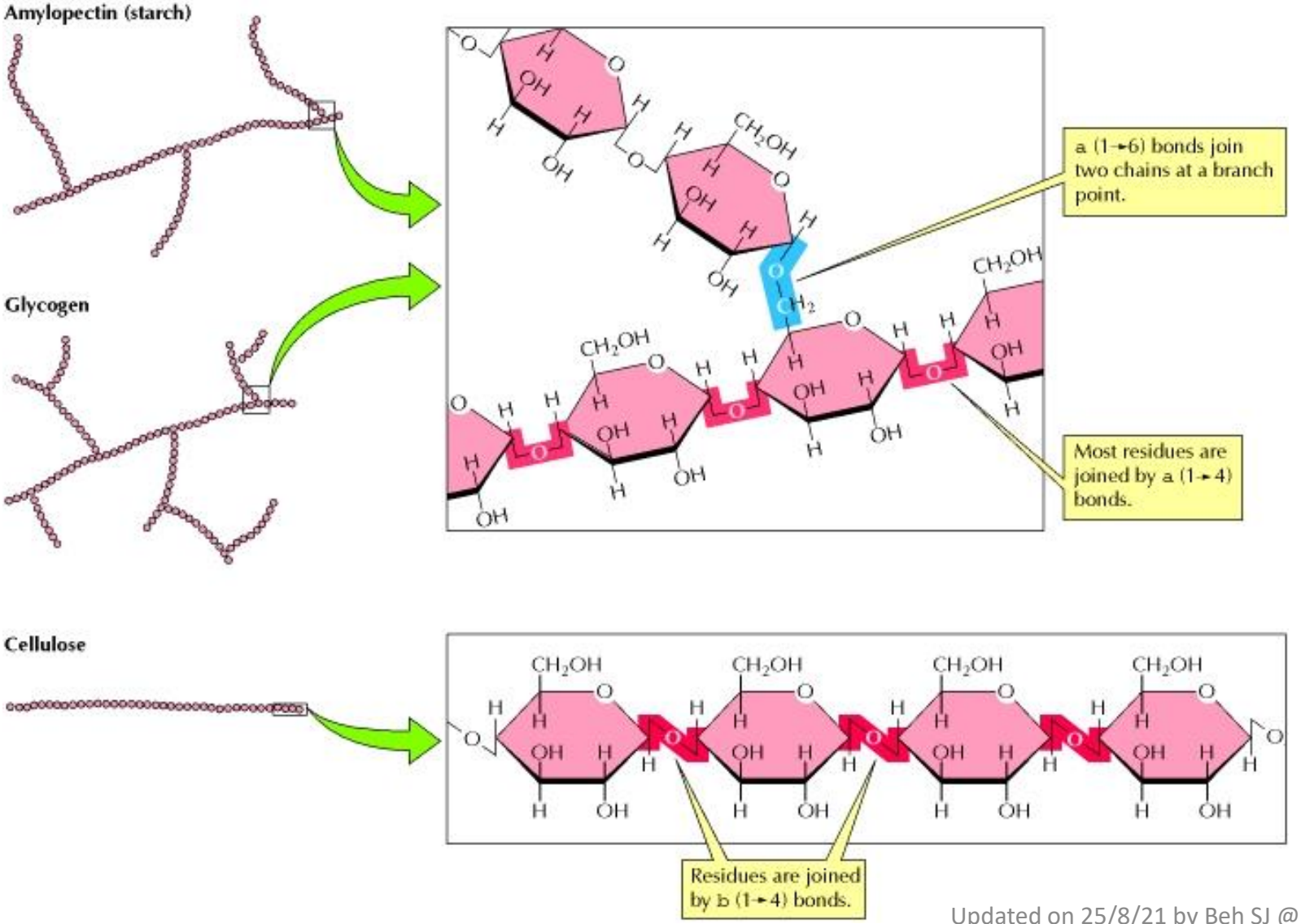
4) Fibres are arranged in a **criss-cross manner**
→ many gaps between fibres
→ cell wall is permeable to water, ions etc.

Updated on 25/8/21 by Beh SJ @behlogy


plant
cell wall
cellulose fibers
5,000 µm
cellulose fiber
microfibrils
glucose molecules
H bonds btwn –OH groups of diff chains
Pro Tip: Dotted lines are often used to represent H bonds

Carbohydrates

Polysaccharides


Amylopectin (starch)
Glycogen
Cellulose
a (1→6) bonds join two chains at a branch point.
Most residues are joined by a (1→4) bonds.
Residues are joined by b (1→4) bonds.

Carbohydrates

Testing the Presence of...

Reducing Sugars	Non-Reducing Sugars
Galactose Glucose Fructose Maltose	Sucrose – the only one you really need to know!

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Testing the Presence of Reducing Sugars

- Reducing sugar: All monosaccharides, disaccharides
- **Except sucrose**

- Add $2cm^3$ of **Benedict's solution** to $2cm^3$ of reducing sugar
- Copper (II) sulphate in alkaline solution
- Blue colour
- Reaction requires heating at 90^oC

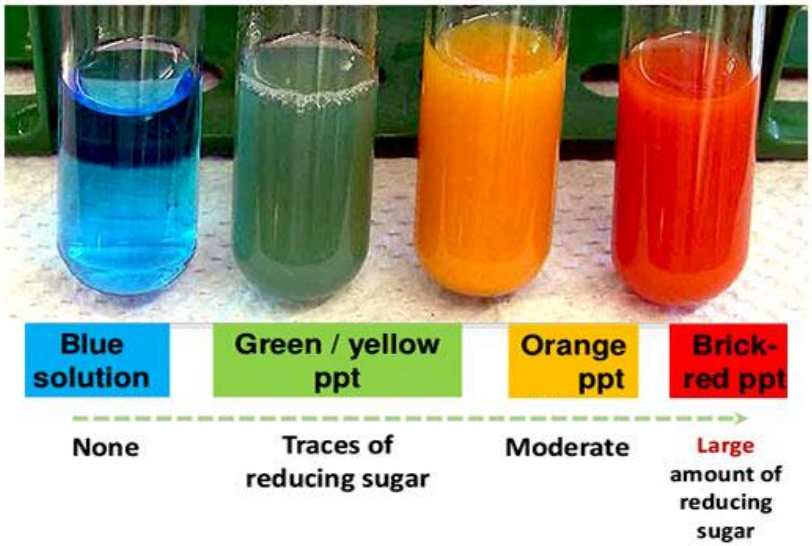
- If reducing sugar is present:

  $Cu^{2+} \rightarrow Cu^{+}$ (in Benedict's sol)

  Blue, soluble → Red, insoluble

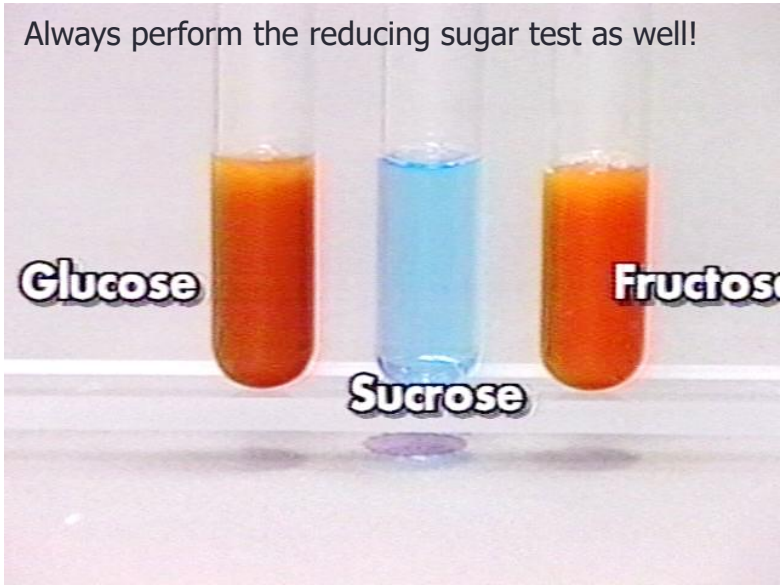
- Forms a brick-red precipitate

(if high conc. of reducing sugar present)



Testing the Presence of Non-reducing Sugars (e.g. Sucrose)

1. Add $2cm^3$ of sample to $2cm^3$ of **acid** to hydrolyse glycosidic bonds → monosaccharides
2. Heat at 90°C
3. **Neutralize** using $2cm^3$ of NaOH
4. Add $2cm^3$ of **Benedict's solution** to $2cm^3$ of the mixture
5. Heat at 90°C



Results:

- Brick red precipitate = Non-reducing sugar
- Even after hydrolysis, remains blue colour

= Not a SUGAR

LIPIDS

Updated on 25/8/21 by Beh SJ @behlogy

Lipids

Made of: C, H , O (sometimes, P)

Important for:

1. Energy storage
   (lipids have many C-H bonds, can generate more E than carbs)
2. Structural component of membranes
3. Other specific biological functions (e.g. hormones)

Monomers:

- Glycerol
- Fatty Acids

Polymers:

- Triglycerides (Fats and oils)
- Phospholipids

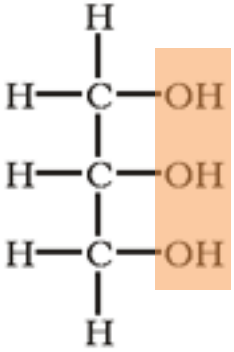
Lipids

Monomers – Glycerol and Fatty Acids

Glycerol

- Has **3 carbons**
- 3 –OH groups

→ functional gp



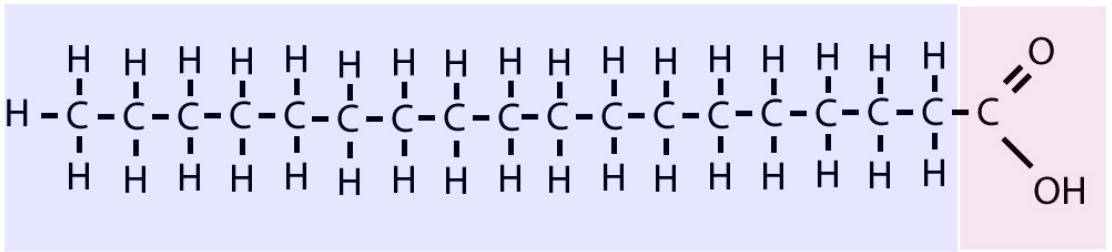
Fatty Acid

- Has an acid "head" (**-COOH** group)

+ a long **hydrocarbon chain**

→ many C-H bonds

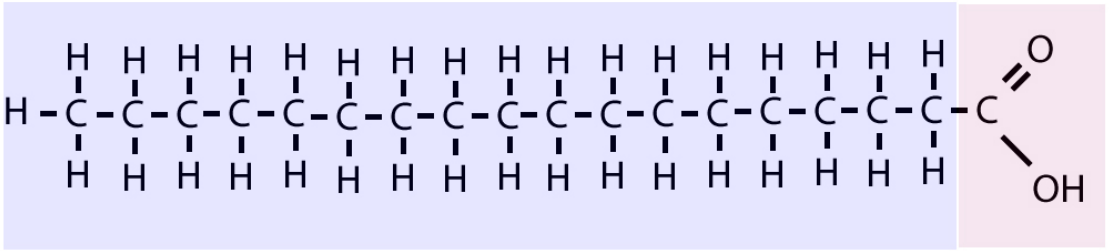
→ hydrocarbon chain is hydrophobic and non-polar



long hydrocarbon chain

carboxylic acid group

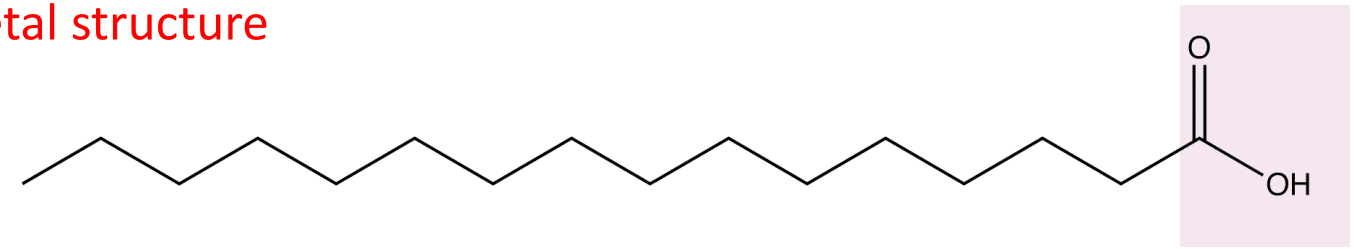
Fatty Acids in Simplified Diagrams



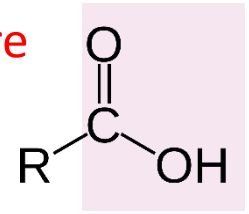
long hydrocarbon chain

carboxylic acid group

skeletal structure



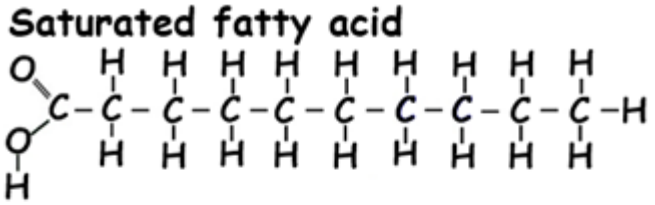
simplified, general structure



Types of Fatty Acids

1) Saturated fatty acids

- No double bonds

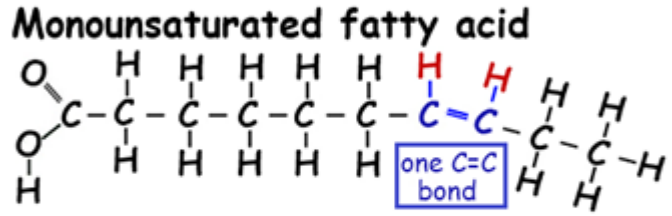


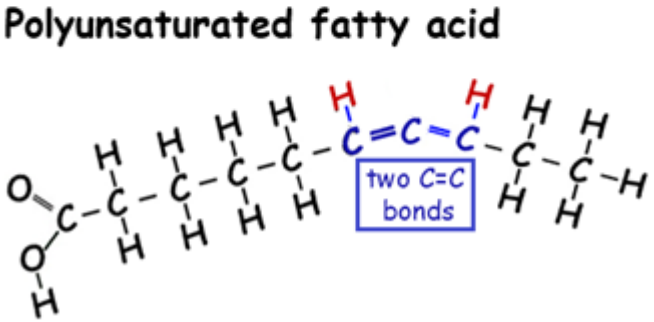
2) Unsaturated fatty acids

- Has double bonds

  Monounsaturated FA = 1 double bond

  Polyunsaturated FA > 1 double bond



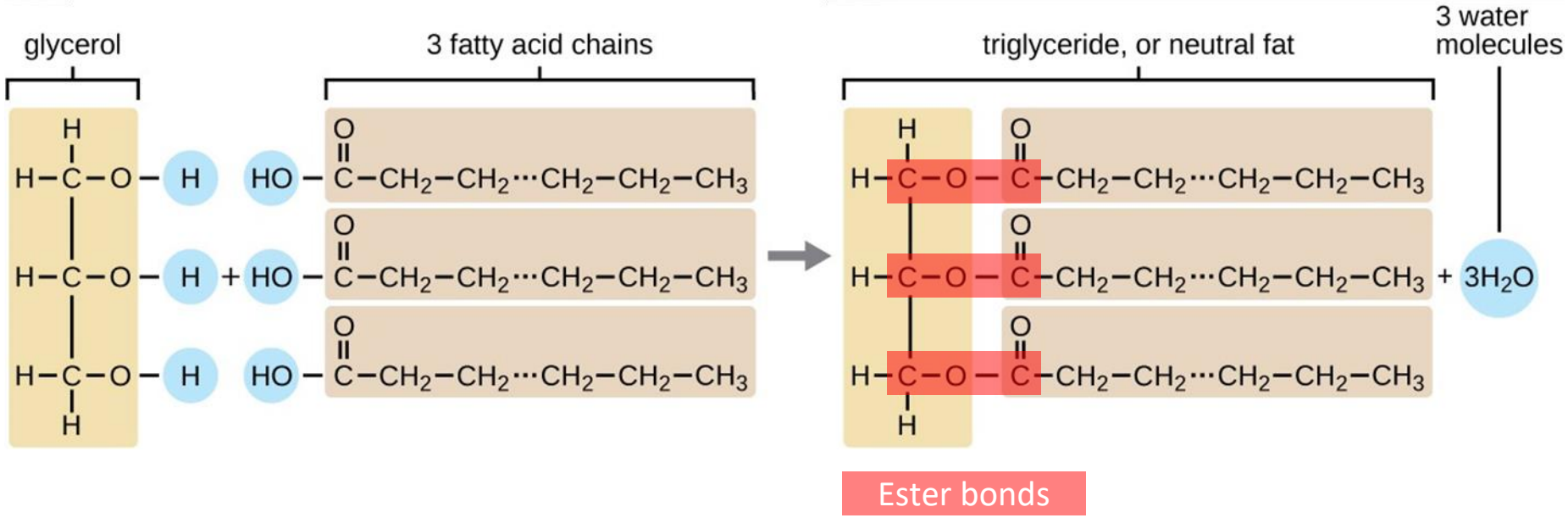


- Results in **kink** in hydrocarbon tail
- Lesser C-H bonds
- Lower melting point – liquid at room temp.

Lipids

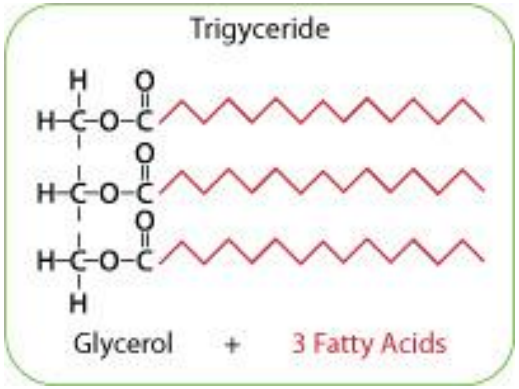
Polymers – Triglycerides

- **3 fatty acids + 1 glycerol**
- Linked by **ester bonds**
- Formed via condensation reactions
- FAs can be unsat. or sat.



Lipids

Polymers – Triglycerides

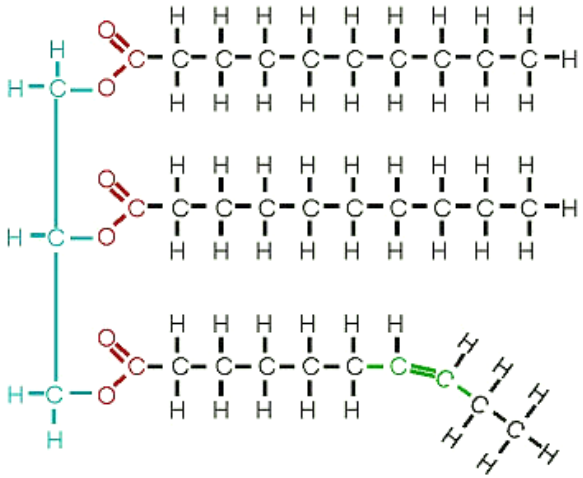


Properties:

- **Insoluble in water**

→ Bcs of the long hydrocarbon tails of the fatty acids

→ Non-polar, hydrophobic



- **Soluble in organic solvents**

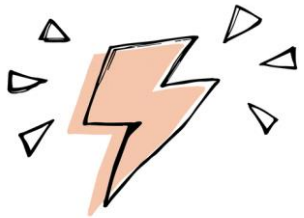
E.g. ether, chloroform, ethanol

Lipids

Polymers – Triglycerides

Roles of Triglycerides:

1) **Source of energy**



→ Many **C-H bonds** (more than carbohydrates)

→ Higher proportion of hydrogen

→ Insoluble, compact

→ **More energy can be produced per unit mass**

2) Metabolic source of **water**

→ High ratio of H to O atoms

→ Release water during fat oxidation

→ especially for desert animals

Lipids

Polymers – Triglycerides

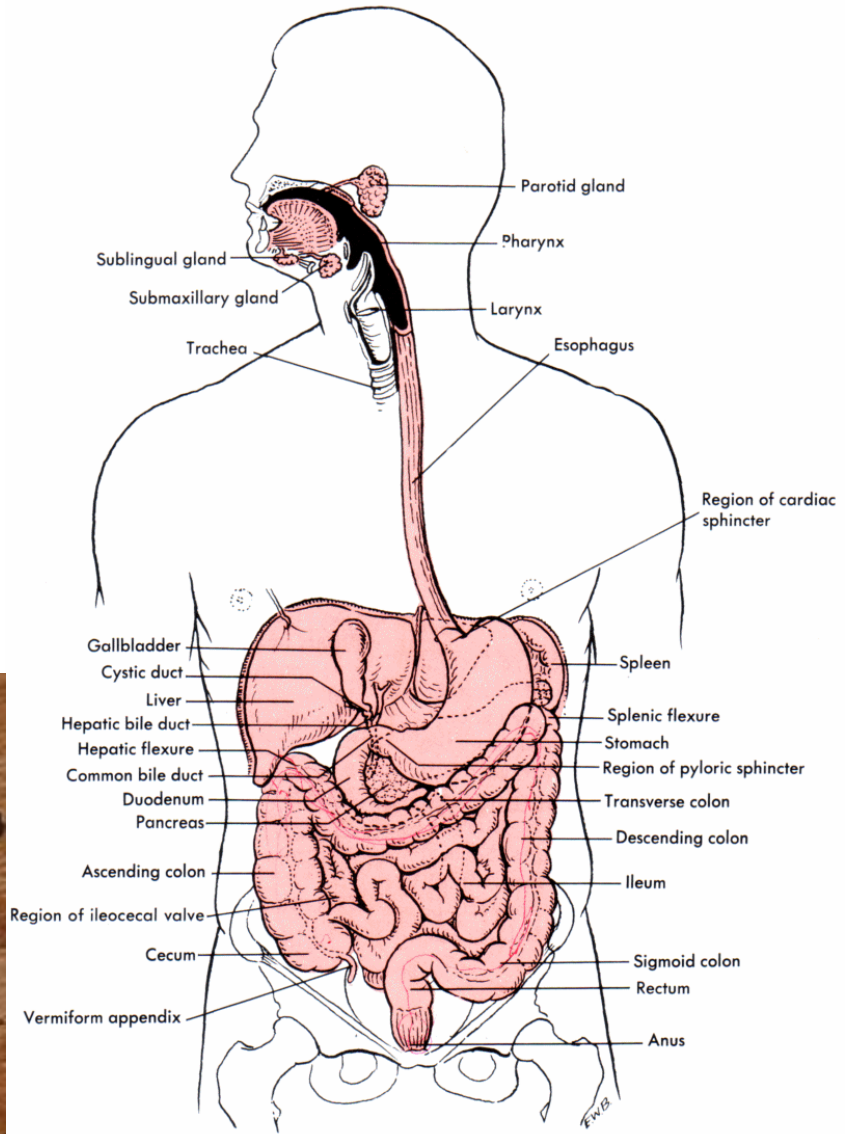
3) Insulator

→ below dermis

4) Protection of organs

5) Buoyancy

→ blubber

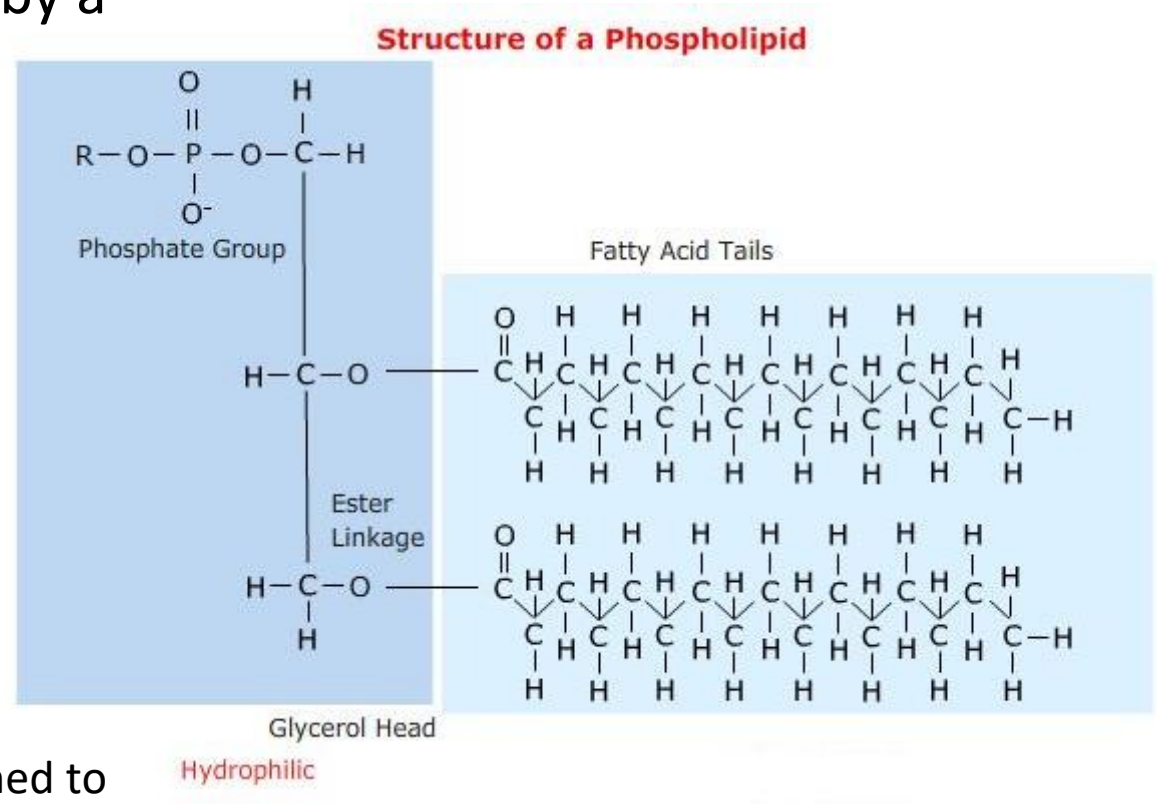


Location of digestive system organs

Lipids

Polymers – Phospholipids

- 1 fatty acid chain in triglyceride is replaced by a phosphate group



Composed of:

- **1 glycerol**
- **2 fatty acids**
- **1 phosphate gp** (PO_4^-)

- May also have other gps attached to phosphate gp (represented by R)

Lipids

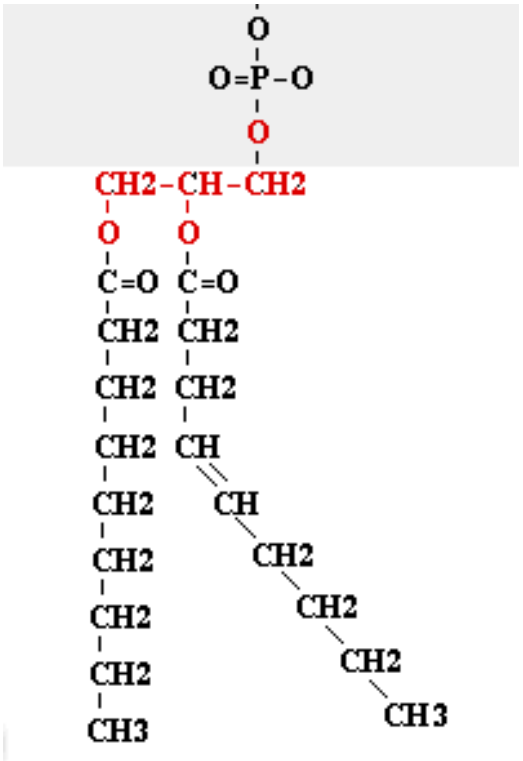
Polymers – Phospholipids

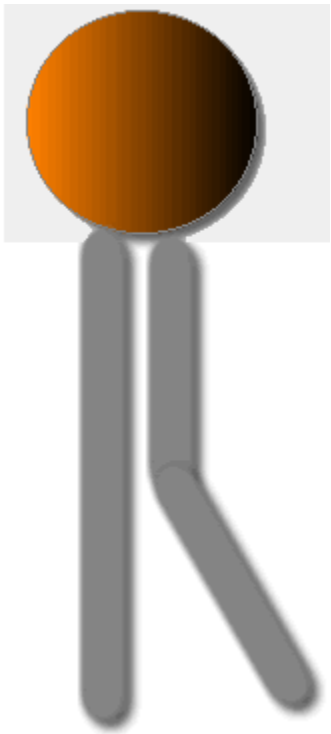
a) **Hydrophilic head**

- **Phosphate group**
- Charged, polar
- Forms H bonds with water

b) **Hydrophobic tails**

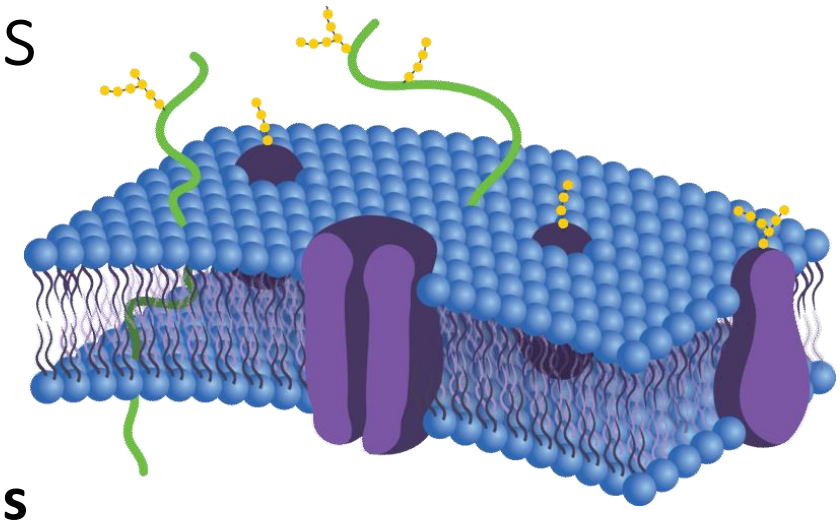
- **Fatty acid residues**
- Hydrocarbon chains are insoluble and non-polar
- Repels water





Lipids

Polymers – Phospholipids



Roles of Phospholipids:

1) Forms a **phospholipid bilayer**

- With **hydrophobic core**
- **Barrier to water-soluble substances at membrane**

2) Allow regulation of **membrane fluidity**

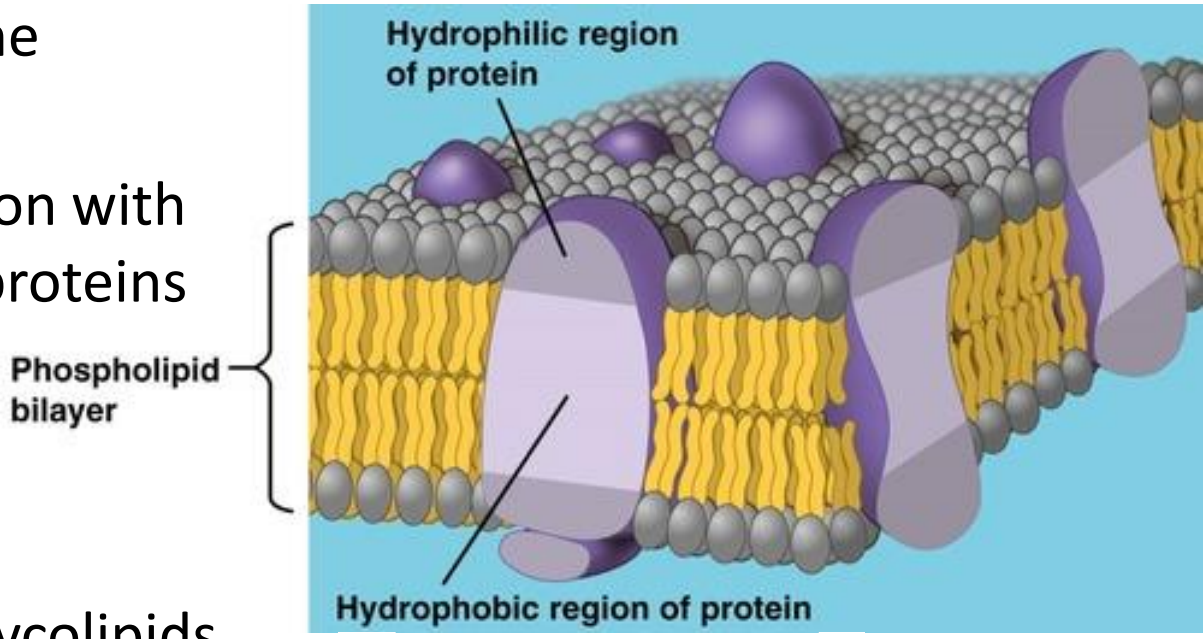
- Double bonds in unsat. fatty acid tails increases fluidity
- Sat. FA decreases fluidity

Lipids

Polymers – Phospholipids

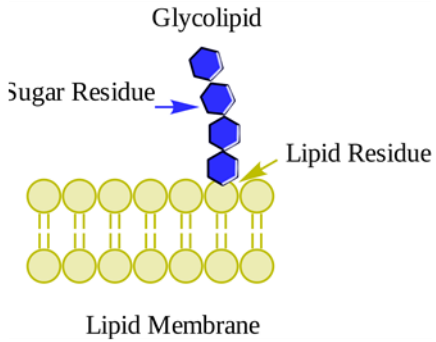
3) Help to hold membrane proteins in place

- Hydrophobic interaction with 'floating' membrane proteins



4) Can combine with carbohydrates to form glycolipids

- Important in cell recognition (more in Chap 4)



Emulsion Test for Lipids

1) Shake sample with ethanol
2) Pour mixture into a tube with water

Results:

- **Transparent** – no lipids
- **White and cloudy** – lipids present

→Lipid molecules clump together

→ Forming little groups dispersed throughout the liquid

→ **Emulsion**

PROTEINS

Updated on 25/8/21 by Beh SJ @behlogy

Proteins

Made of: C, H, O, N (sometimes, S)

Examples of structures made of protein:

- **Haemoglobin**
- **Collagen**
- **Components of cell membranes**
- **Enzymes**
- Antibodies
- Keratin

Monomer: **Amino acids**

Dimer: **Dipeptide**

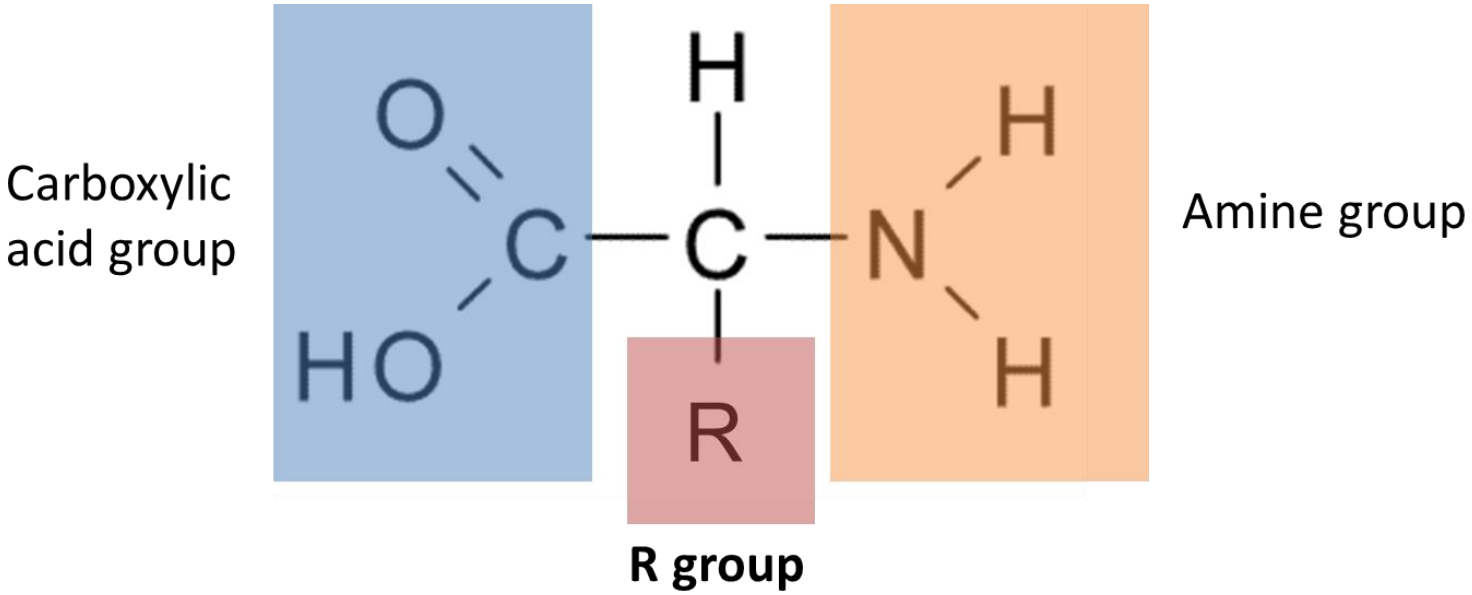
Polymer: **Polypeptide**

Proteins

Monomer – Amino acids

You need to know how to draw the general structure of amino acids!

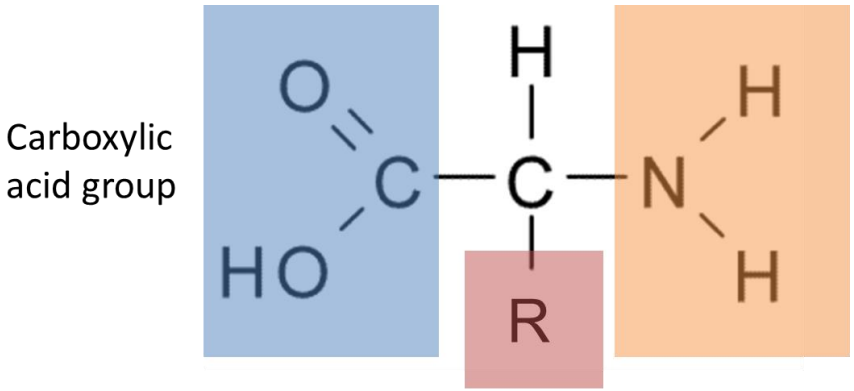
The general structure of amino acids:

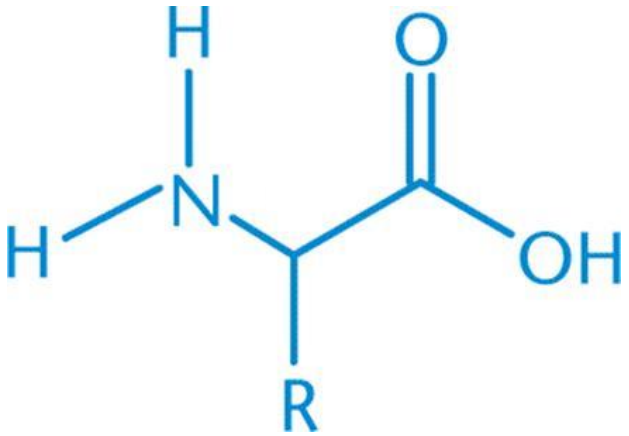


There are 20 types of R groups
→ 20 different amino acids

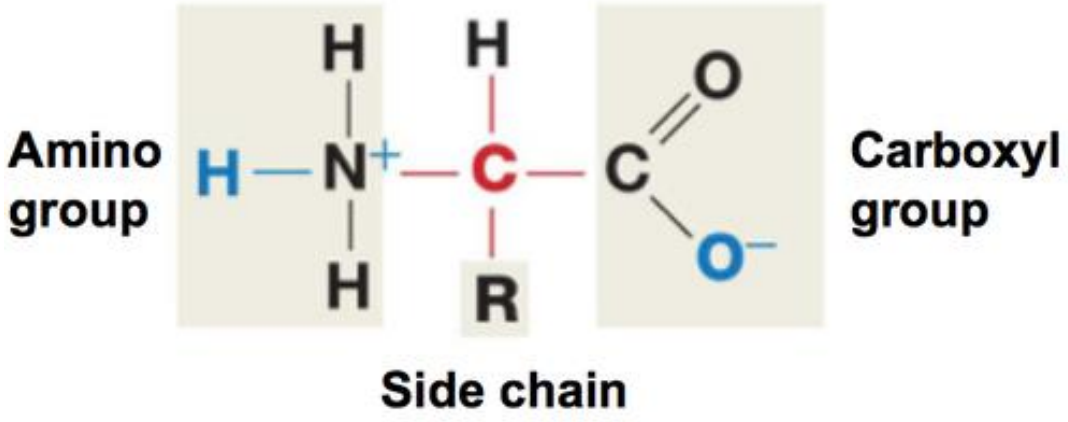
Proteins

Monomer – Amino acids





skeletal structure



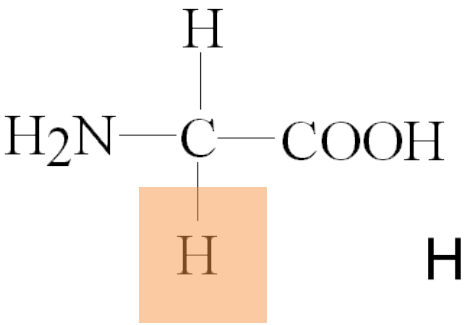
a.a. are in an ionized state in water

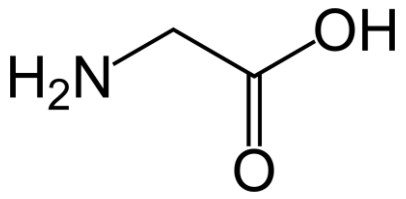
Proteins

Monomer – Amino acids

You need to know how to draw glycine!

E.g. types of amino acids



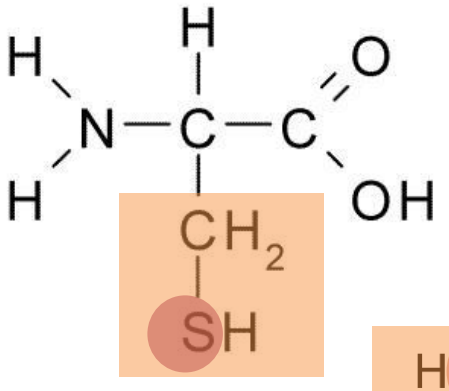


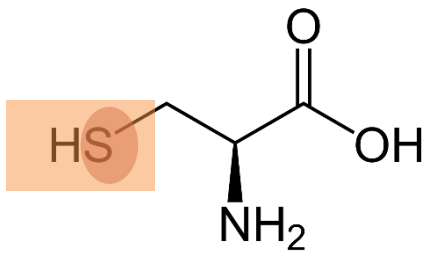
The simplest amino acid is **glycine**

R group = H

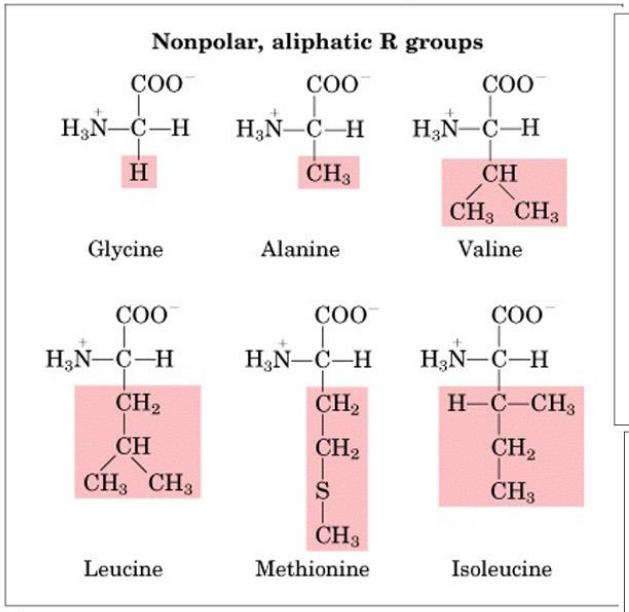
One more name to rmb is **cysteine**

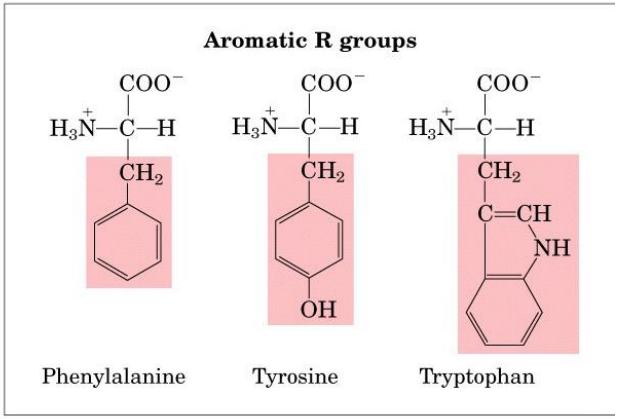
R group = contains sulphur

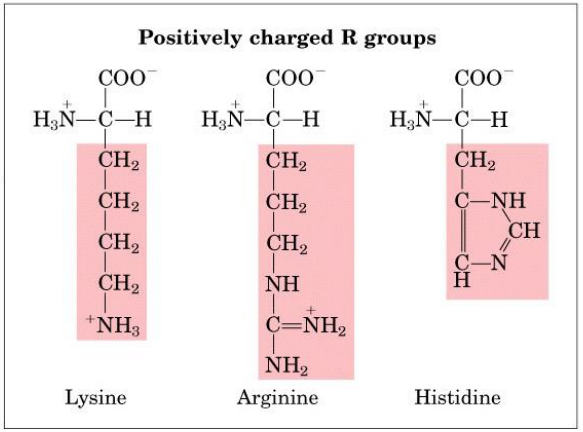


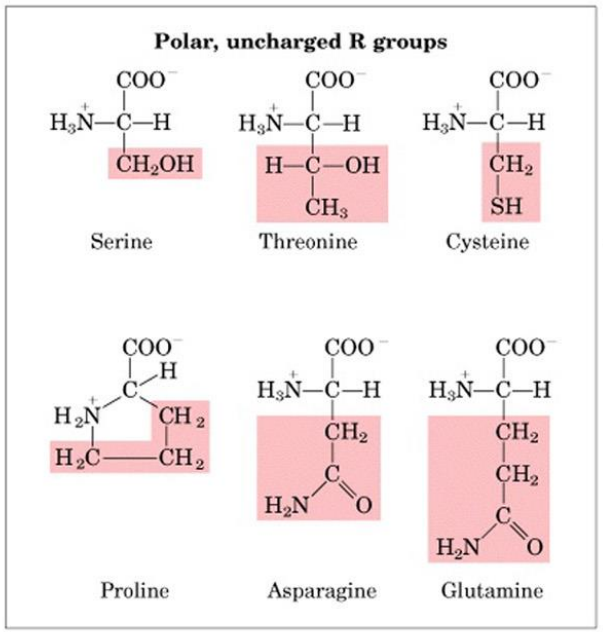


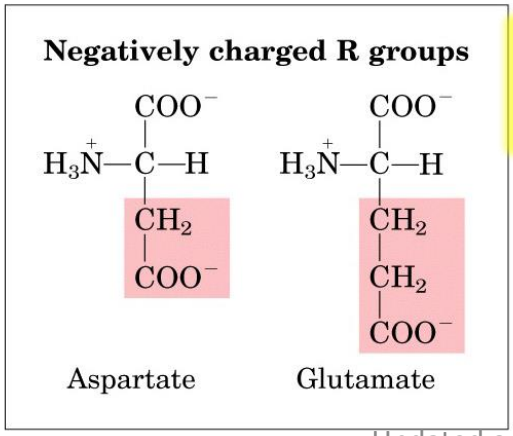
Twenty standard Amino Acids







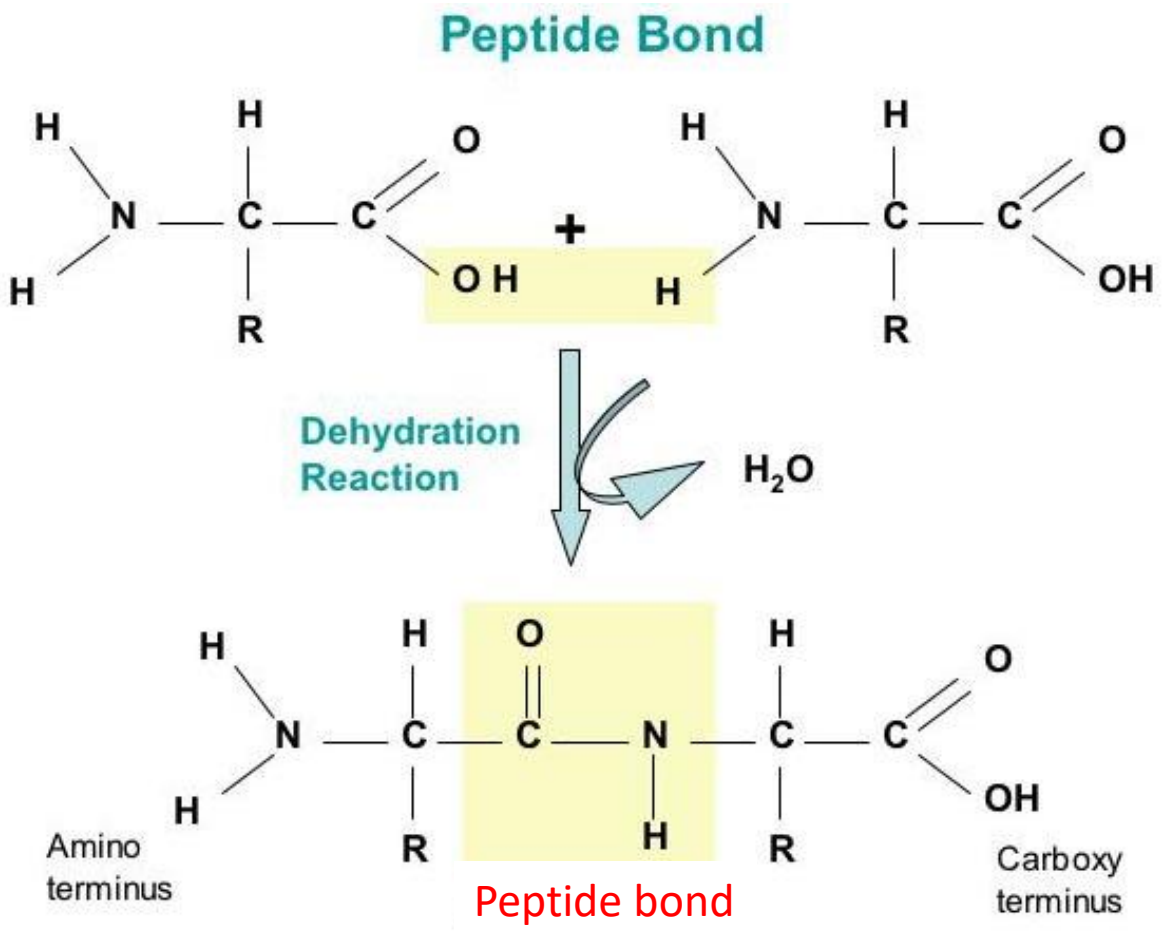




You DO NOT need to memorise this!

Proteins
Dipeptides

You need to know how to draw products of condensation / hydrolysis reactions!

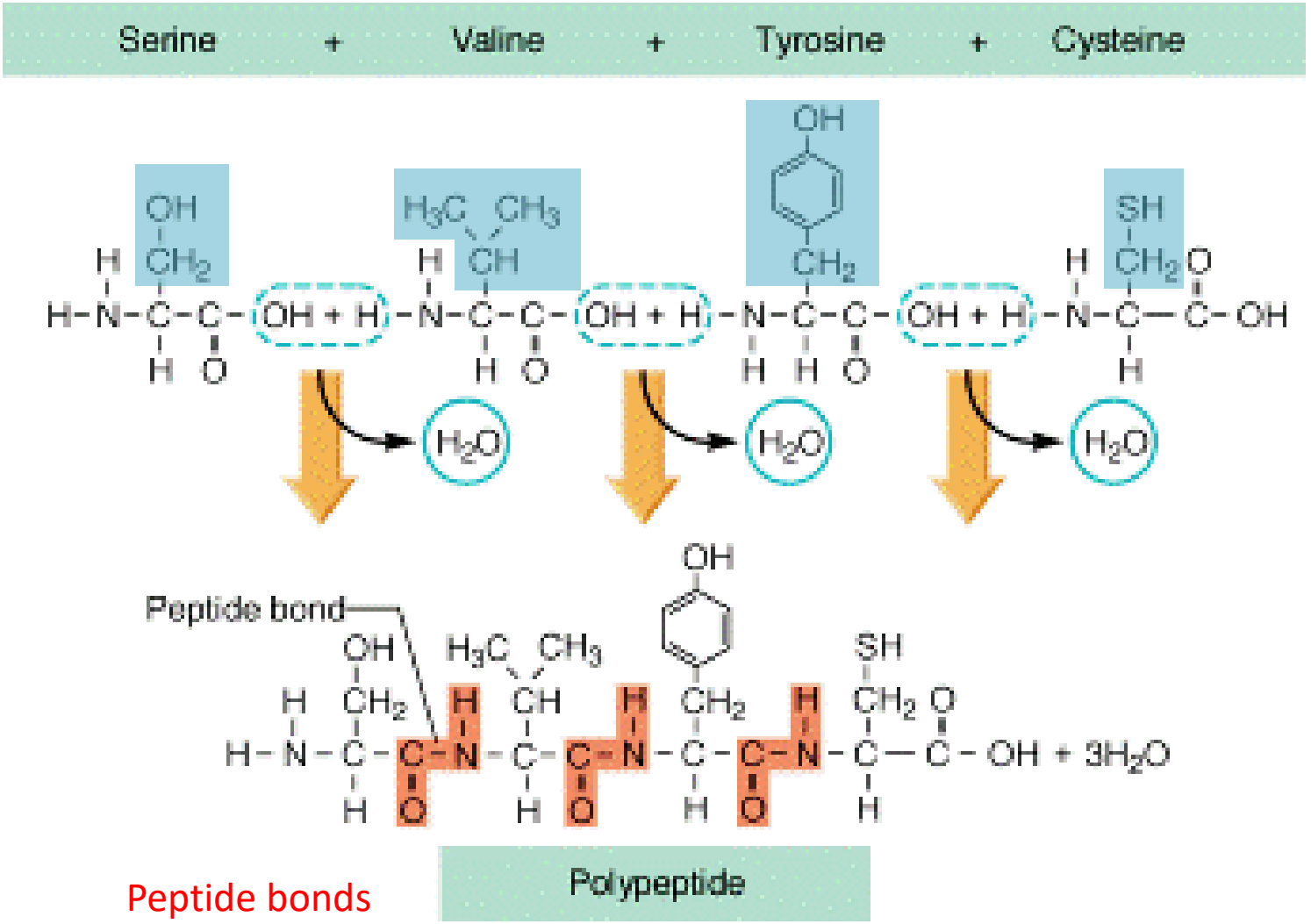


Peptide bond forms between C of –**C**OOH and the N of –**N**H2

Proteins

Polypeptides

- Synthesised at the ribosome
- Condensation reaction



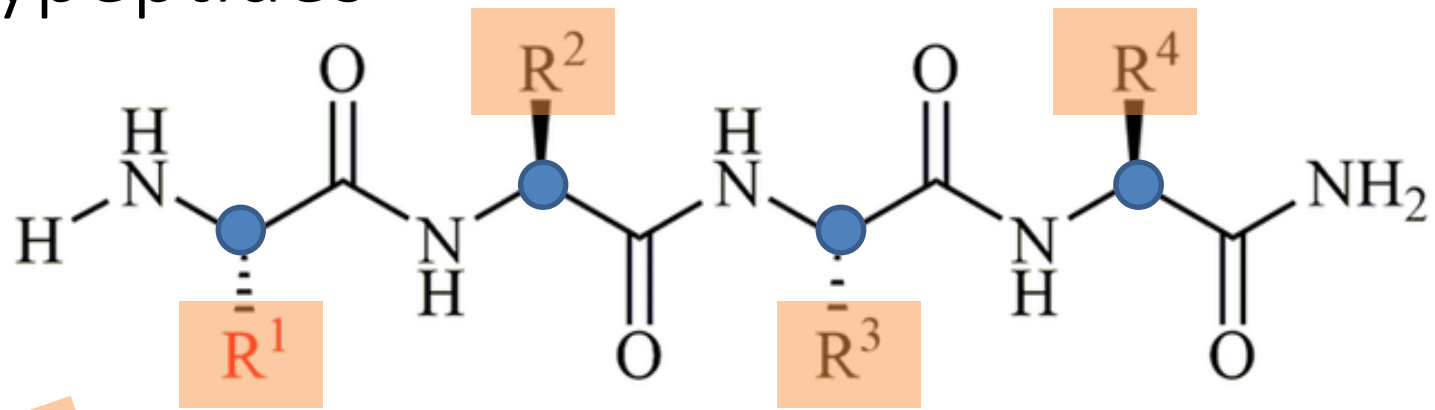
Peptide bonds

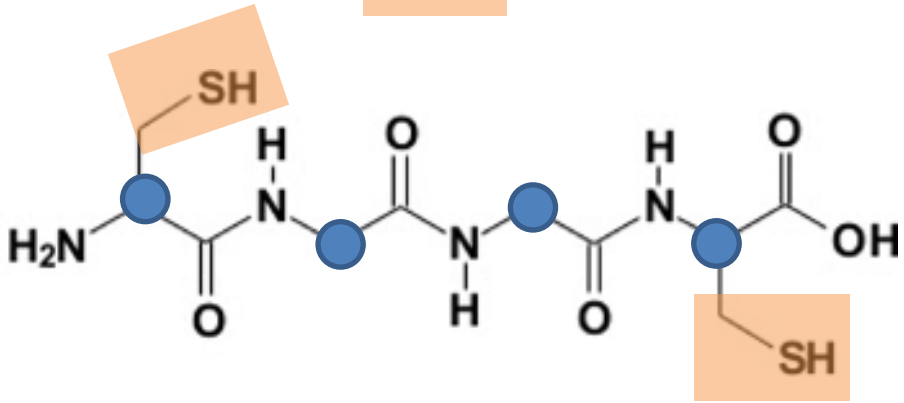
Proteins

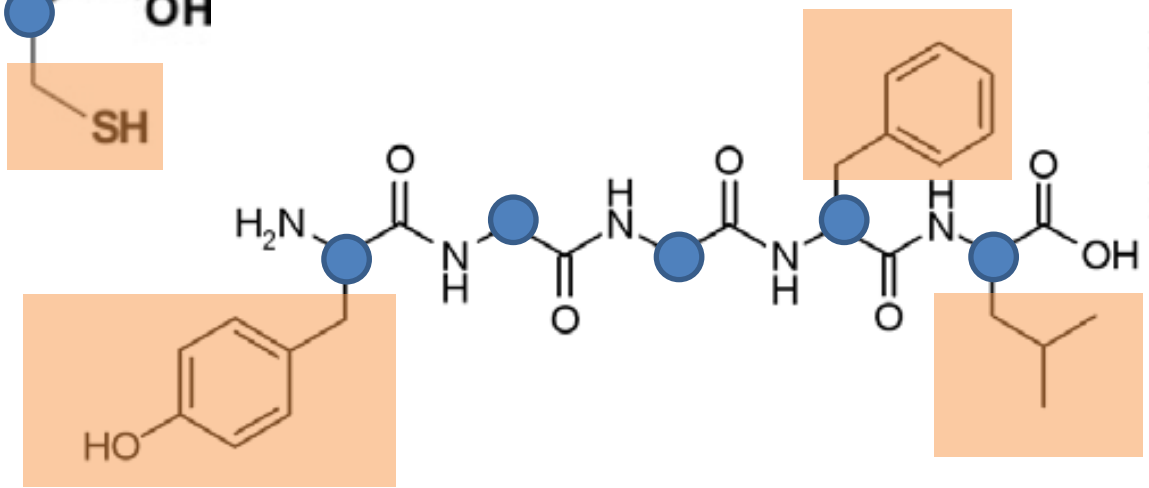
Polypeptides

= central carbon atom

= R group





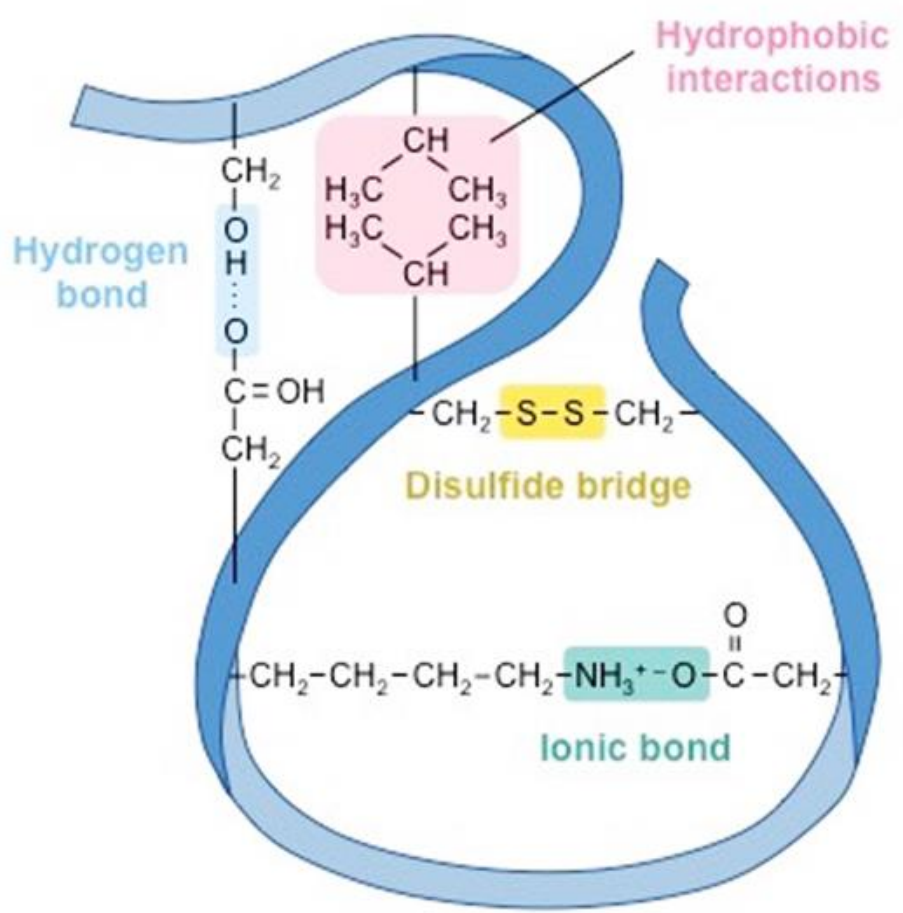


Protein

4 types of bonds

Peptide bonds
(present in all polypeptides)

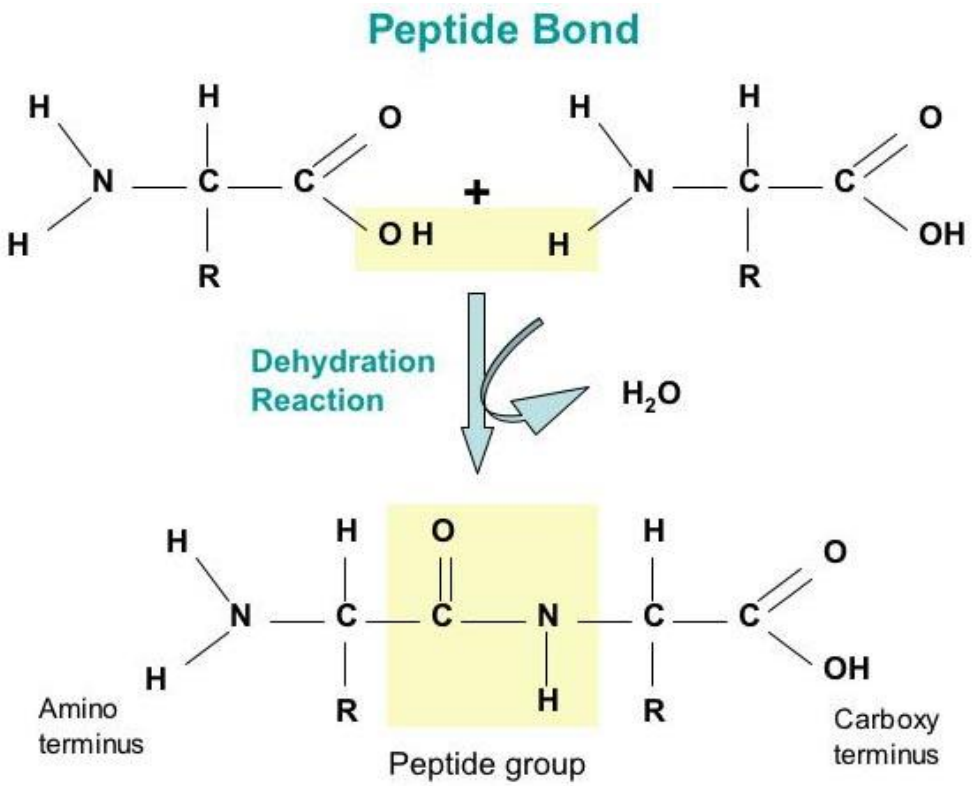
1. Hydrogen bonds
2. Disulfide bonds
3. Ionic bonds
4. Hydrophobic interactions



Peptide bonds

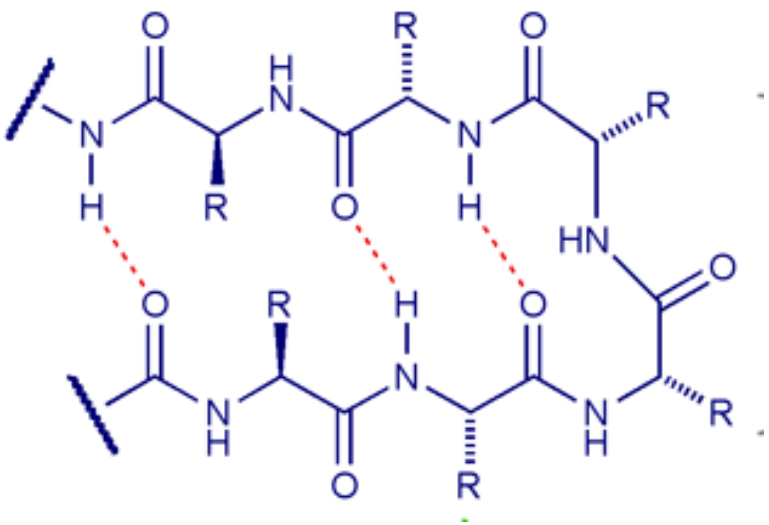
- Very Strong
- **Covalent** bonds
- Between C of –**C**OOH and the N of –**N**H2
- Result of condensation reaction

- Present in all polypeptides



1. Hydrogen Bonds

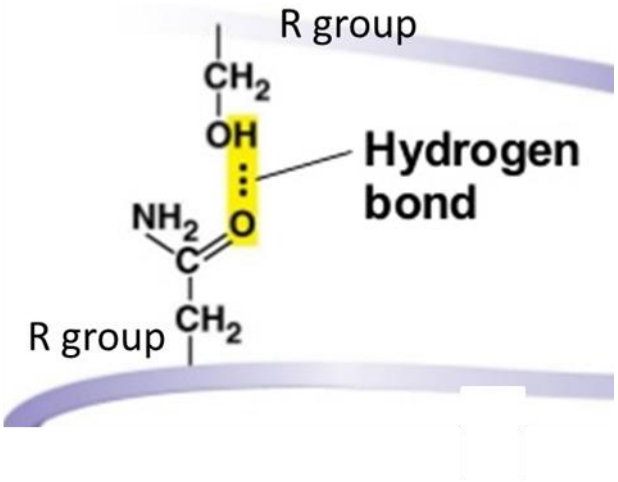
- Individually weak
- But many H bonds
  → cumulatively strong



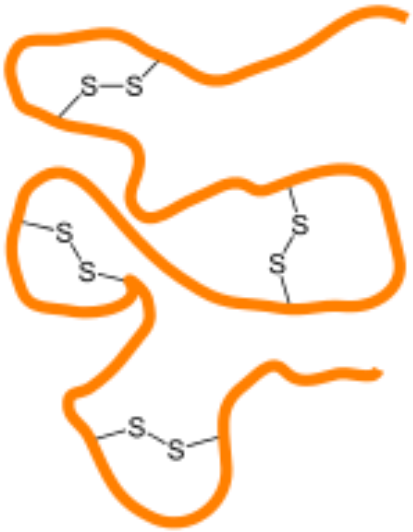
- Between H of –N**H** / – O**H** group and O of –C**O** group
- OR between **R groups**

Easily broken by:

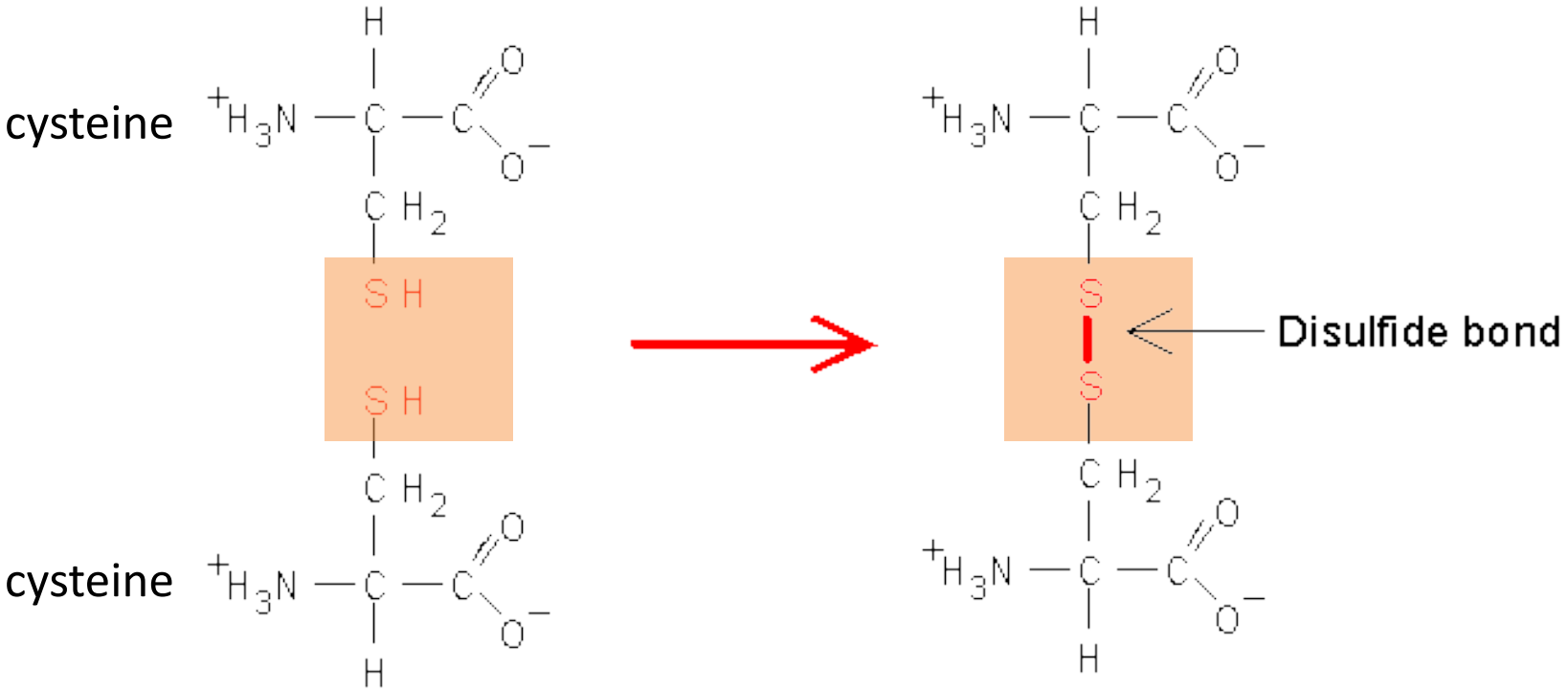
- **High temperatures**
- **pH changes**



2. Disulfide Bonds



- Very strong **covalent** bonds
- Between **sulphur** atoms of **cysteine** amino acids



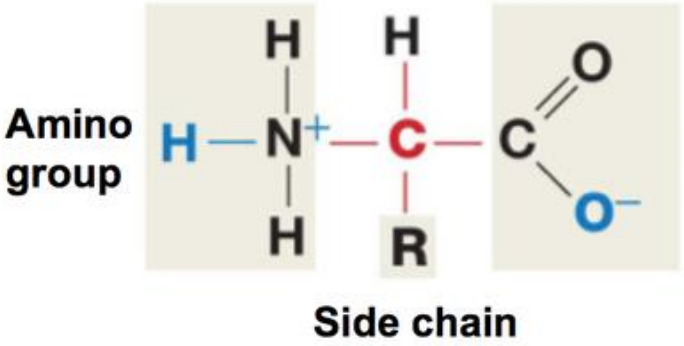
3. Ionic Bonds

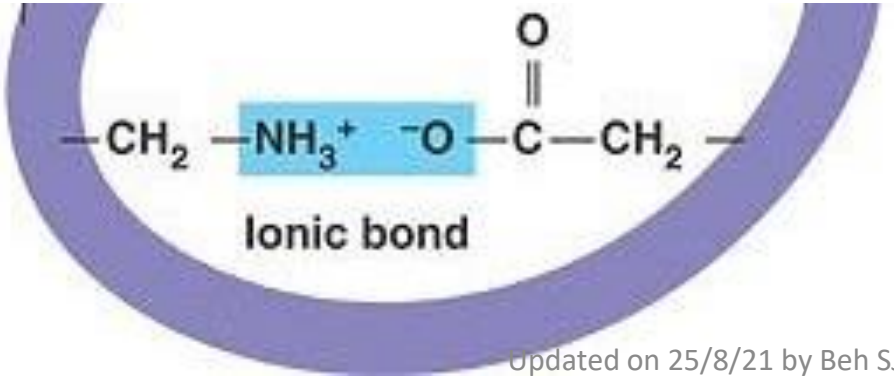
- Between **ionized amine** and **carboxylic acid** groups

→ **– NH_3^+ and – COO^- groups**

→ that are not involved in peptide bonding

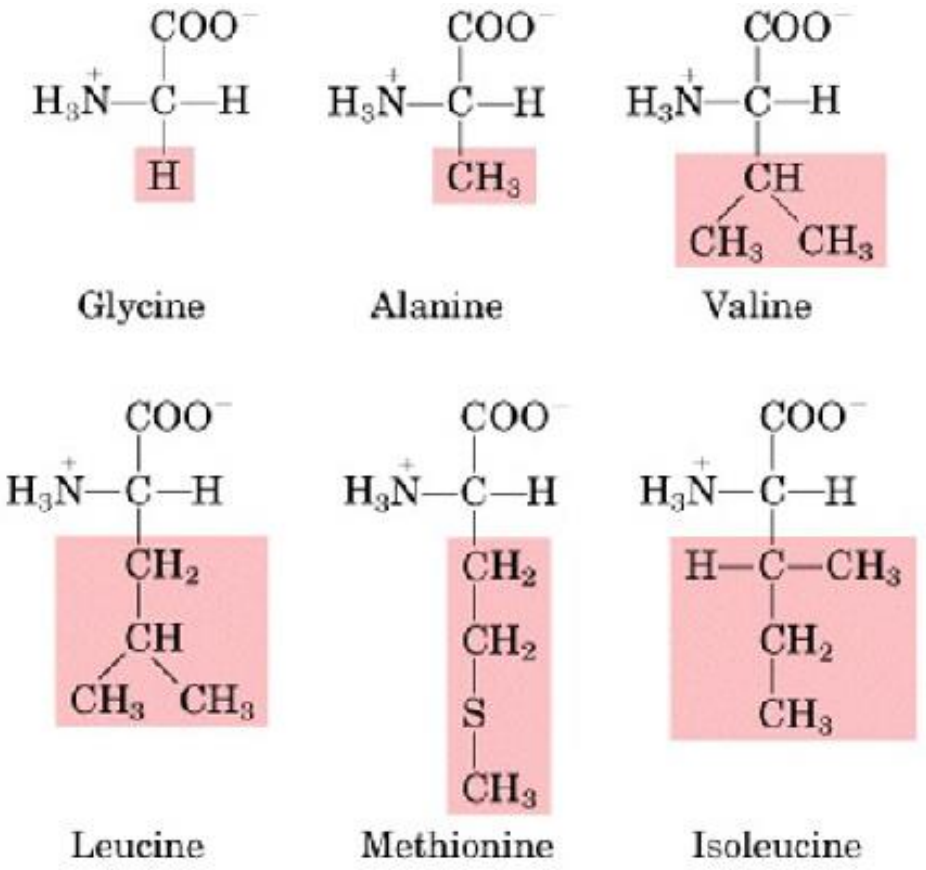
- **OR** between **charged R groups**
- Weaker than disulphide bonds, but stronger than H bonds
- Easily broken down by **pH changes and high temp**





4. Hydrophobic Interactions

- Between **non-polar / hydrophobic R groups**
- Repel and move away from water
- Weakest

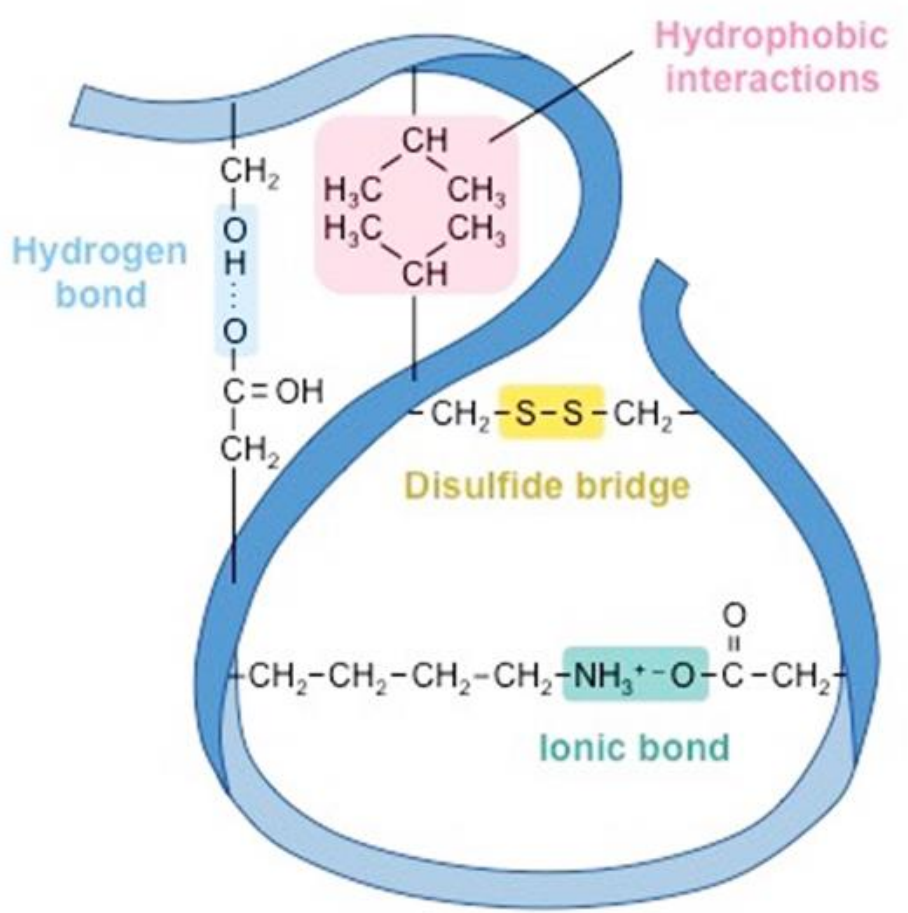


Protein

4 types of bonds

Weakest → Strongest

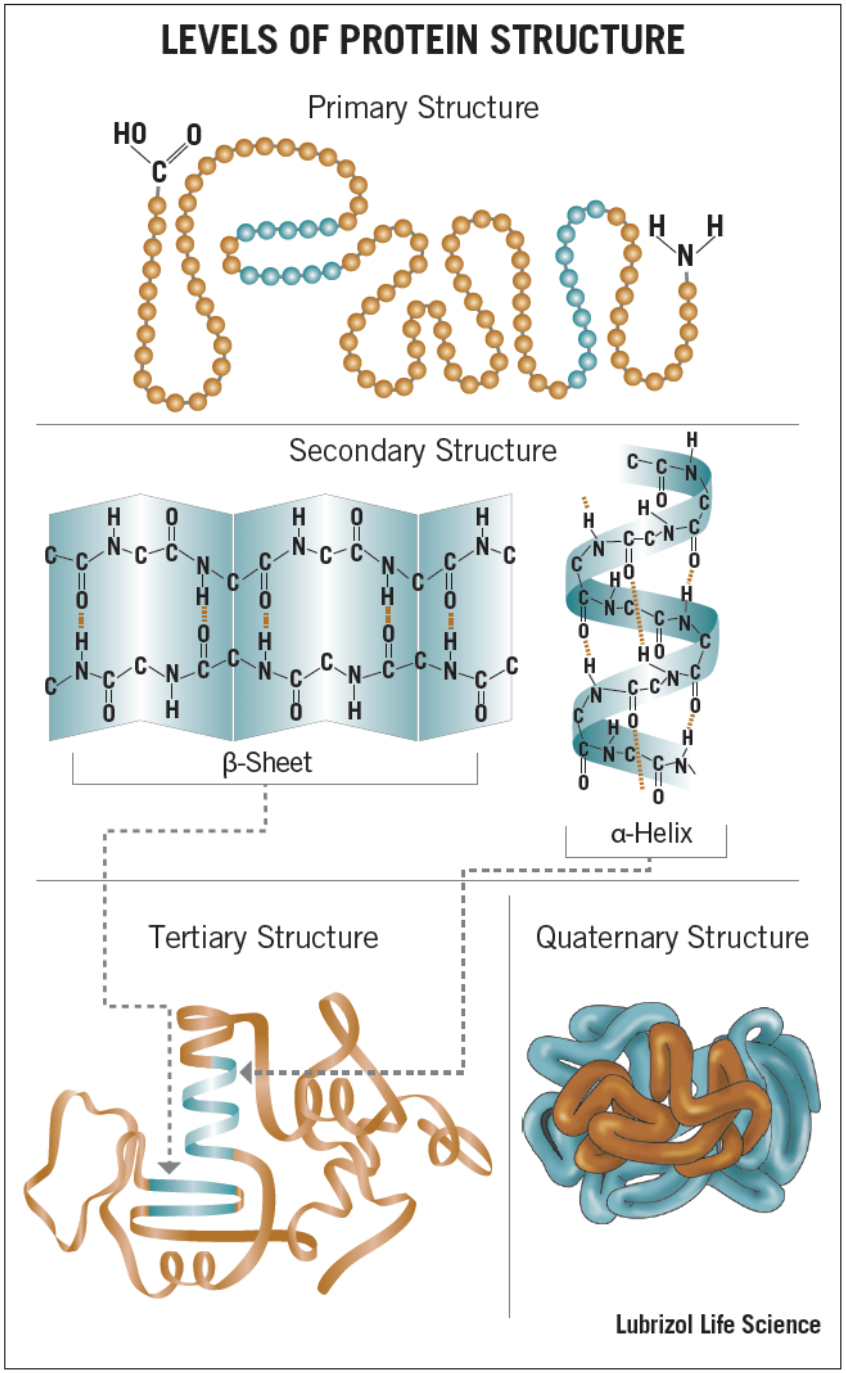
1. Hydrophobic interactions
2. H bonds
3. Ionic bonds
4. Covalent bonds
   i.e. disulphide bonds,
   peptide bonds



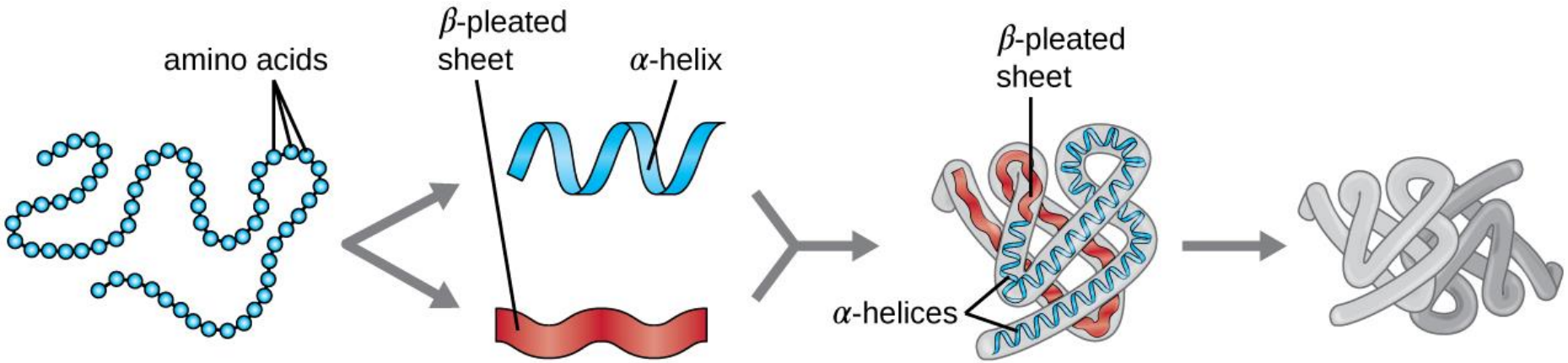
Proteins

4 levels of protein structure

- Primary structure
- Secondary structure
- Tertiary structure
- Quaternary structure



4 Levels of Protein Structure



Primary Protein Structure
Sequence of a chain of amino acids

Secondary Protein Structure
Local folding of the polypeptide chain into helices or sheets

Tertiary Protein Structure
three-dimensional folding pattern of a protein due to side chain interactions

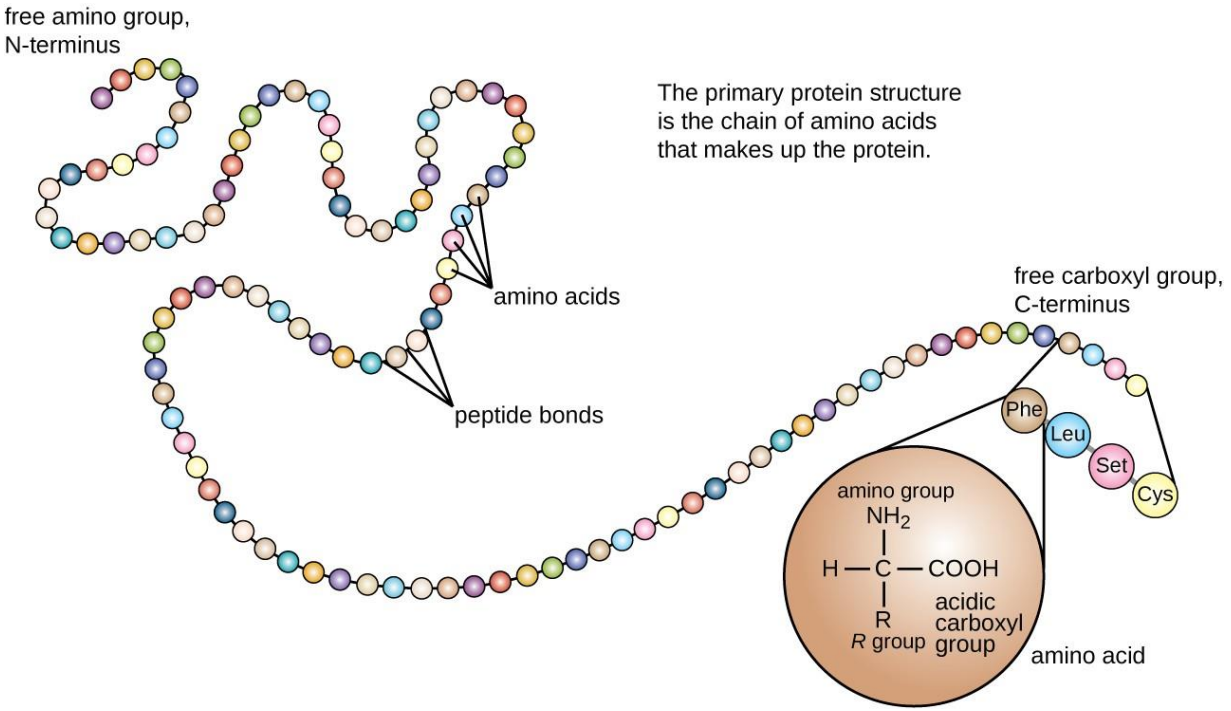
Quaternary Protein Structure
protein consisting of more than one amino acid chain

Primary Structure

- **Linear sequence of amino acids**
- Held together by **peptide bonds**
- Specific seq of amino acids

→ each with diff properties of R groups

→ Dictates folding of the polypeptide chain

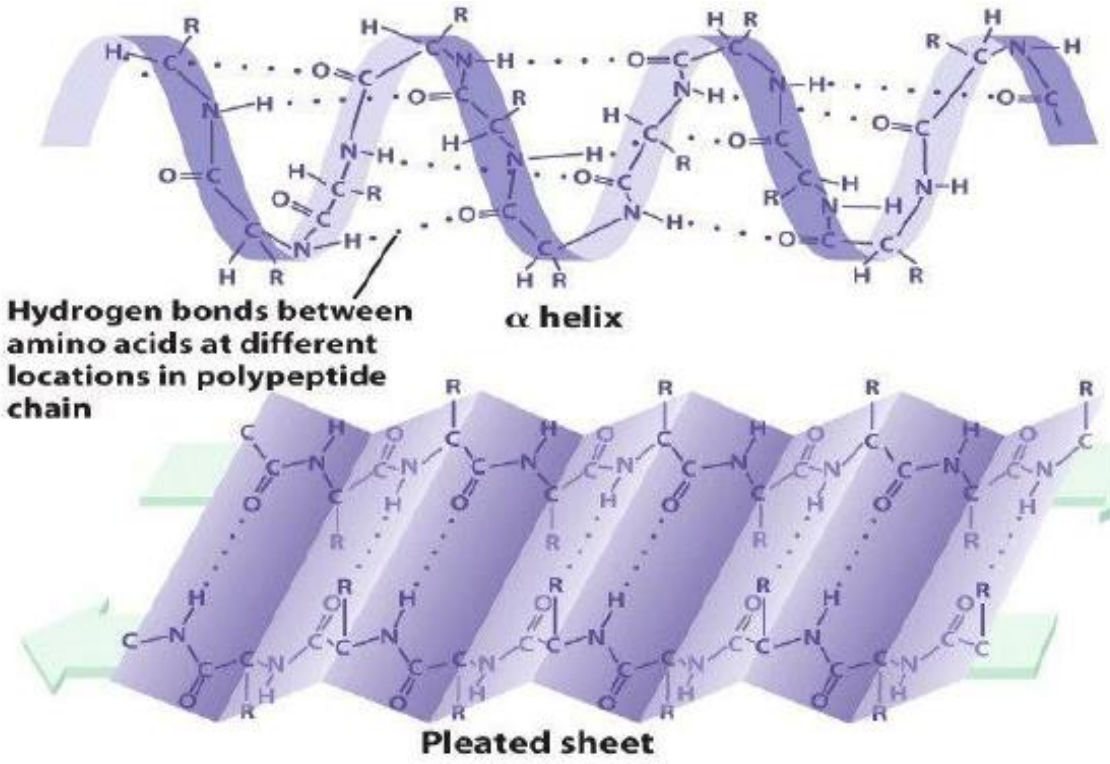


Secondary Structure

- **H bonds** between amino acids
- Not located directly next to each other
- Of the same polypeptide chain

Two conformations:

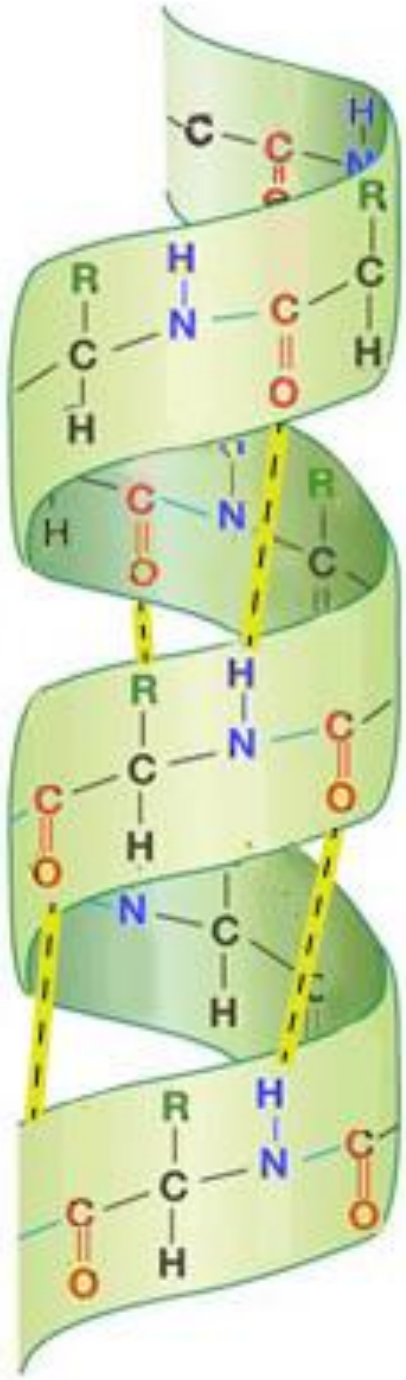
1) **α - helix**
2) **β - pleated**



Secondary Structure

1) α - helix

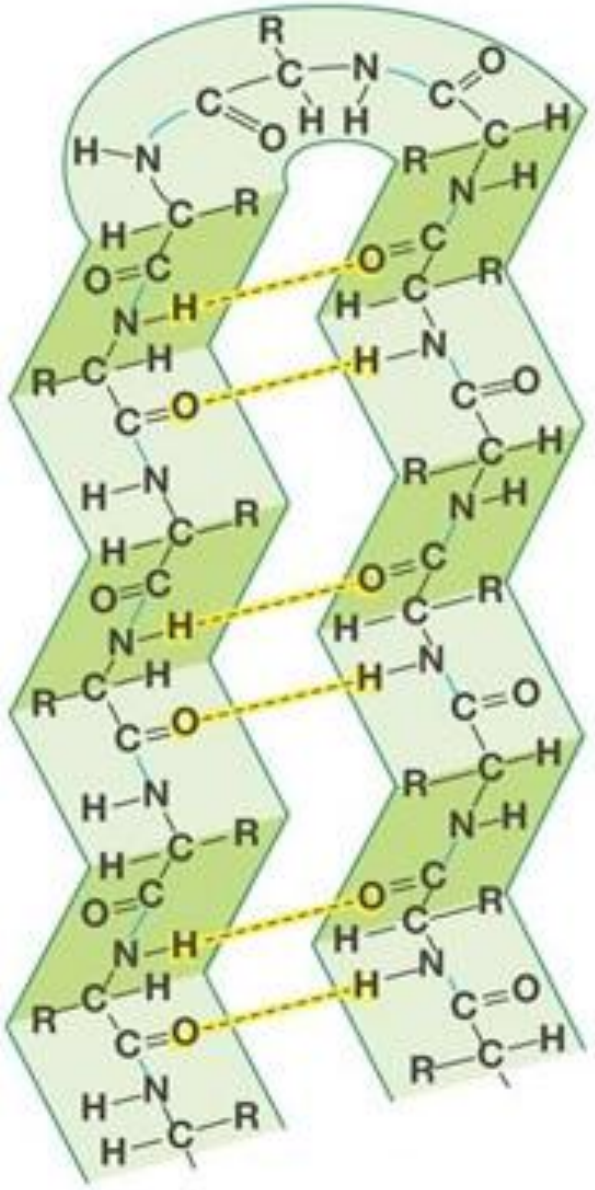
- **Hydrogen bonding**
- between H atom of the -N**H** group and O atom of the -C**O** group
- 4 places ahead
- Forms spring-like structures



Secondary Structure

2) β - pleated sheets

- **Hydrogen bonding**
- between H atom of the -N**H** group and O atom of the -C**O** group
- Straighter, looser form
- Parallel, flat sheets

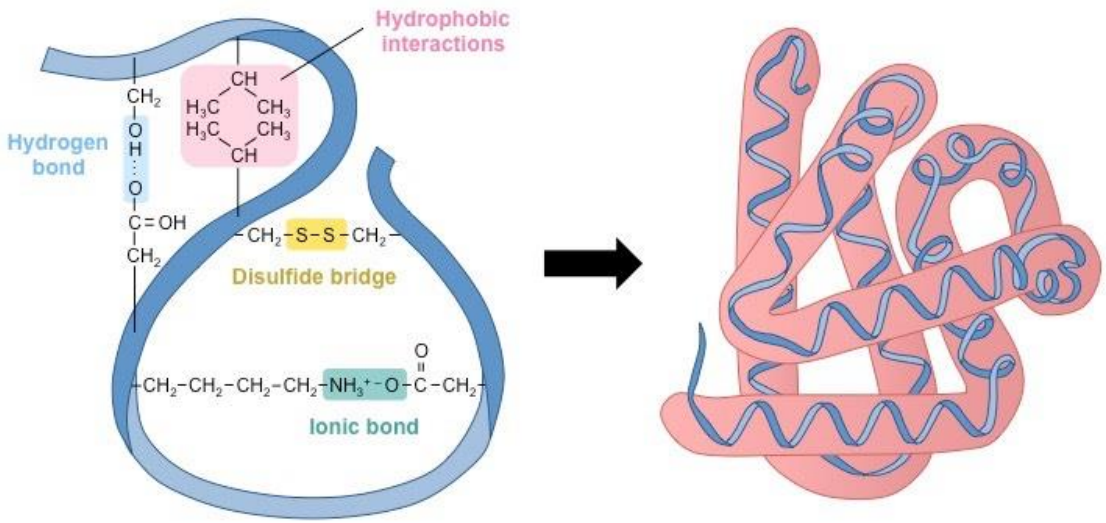


Tertiary Structure

- **Coiling and folding** of secondary structures

→ Into a precise **3D structure**

- Due to interactions between R groups
- One polypeptide chain only
- Could be held by **all 4 bonds** – H bonds, disulfide, bonds, ionic bonds, hydrophobic interactions



Types of side chain interactions

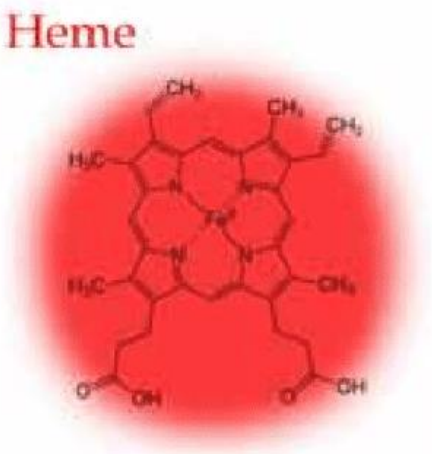
Overall 3D shape (3° Structure)

Tertiary Structure

E.g. **myoglobin**

- Oxygen-carrying molecule
- Present in muscle cells

→ gives it a red colour

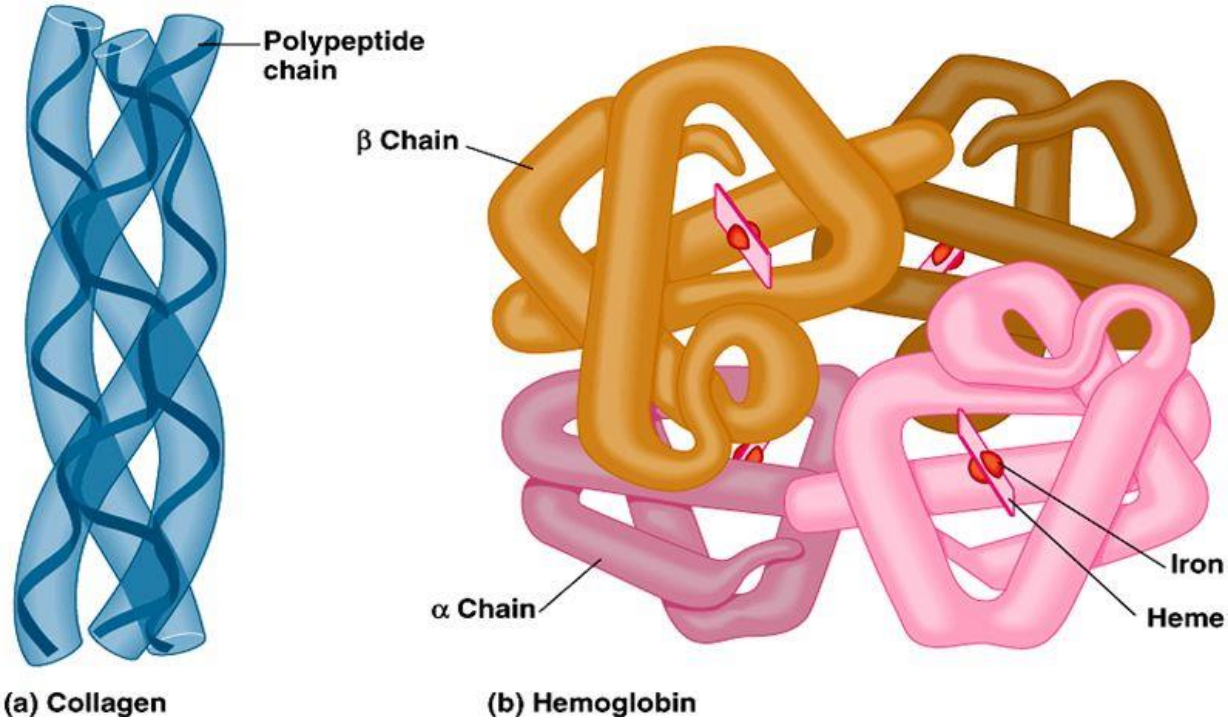


- Made of 1 polypeptide chain
- Has a haem group = non-amino acid group
- That binds 1 molecule of oxygen

Quaternary Structure

- Combination of **two or more polypeptide chains**
- Held together by **all 4 bonds**

E.g. Haemoglobin, collagen



Q: Which levels of protein structure are demonstrated by a haemoglobin molecule?

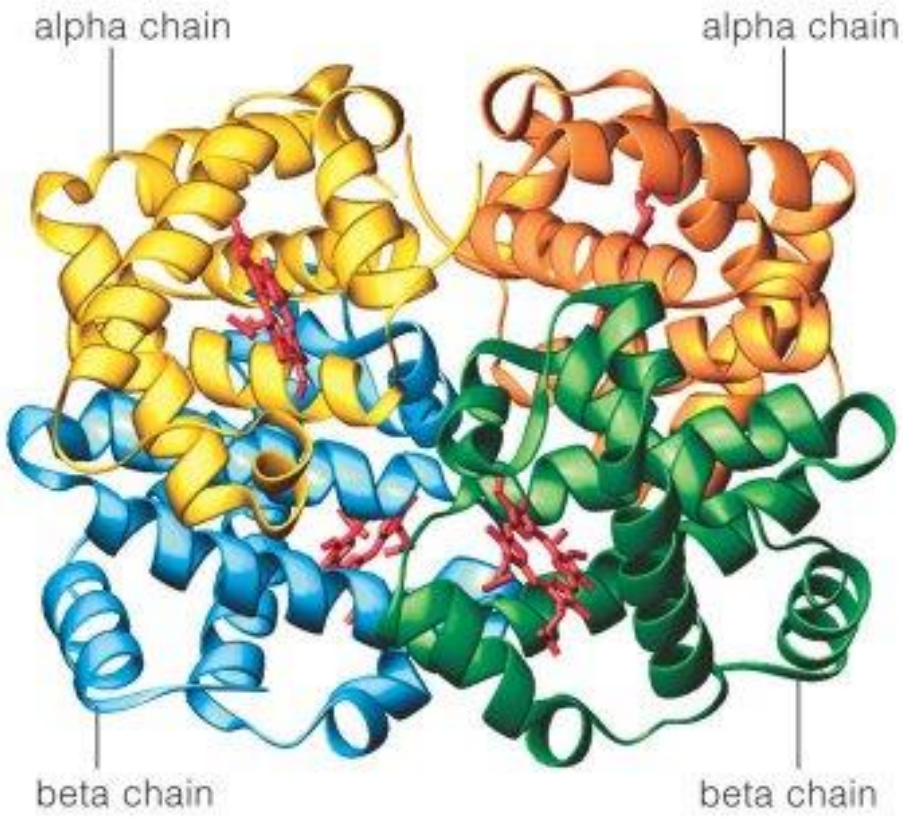
A:

primary

secondary

tertiary

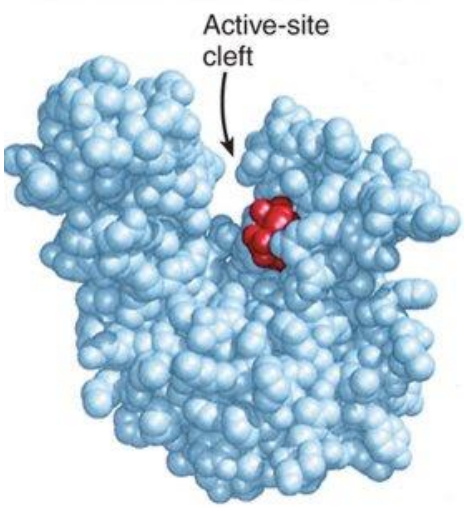
quaternary



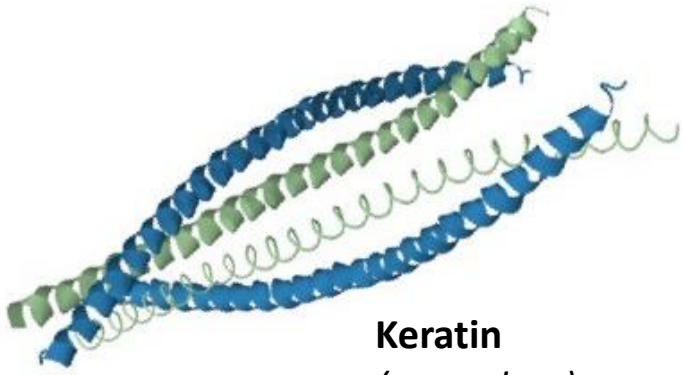
Proteins

Globular vs Fibrous Proteins

Globular Proteins	Fibrous Proteins
Spherical / ball shape	**Long, parallel strands**
Mostly tertiary, sometimes quaternary structure	Mostly secondary structure and forms fibers
Soluble More functional roles	**Insoluble** More structural roles
E.g. All enzymes, antibodies, some hormones, myoglobin, haemoglobin	Eg: Collagen, keratin



Enzyme
(tertiary/quaternary)



Keratin
(secondary)

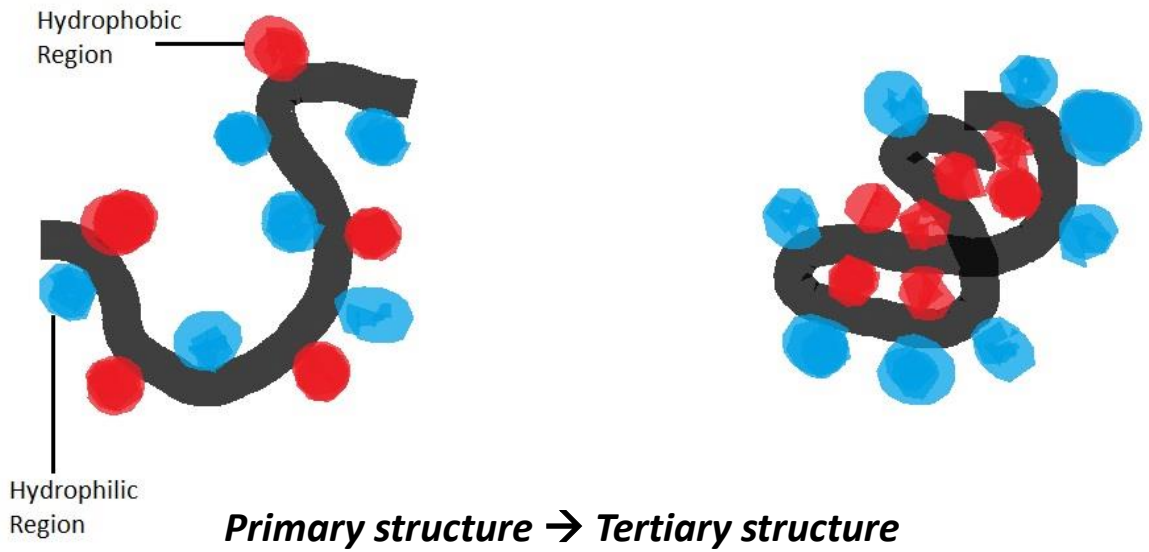
Proteins

Globular Proteins

Q: What makes globular proteins soluble?

A:

- Amino acids with non-polar / **hydrophobic R groups** are **inside**
- Amino acids with polar / **hydrophilic R groups** faces **outside**



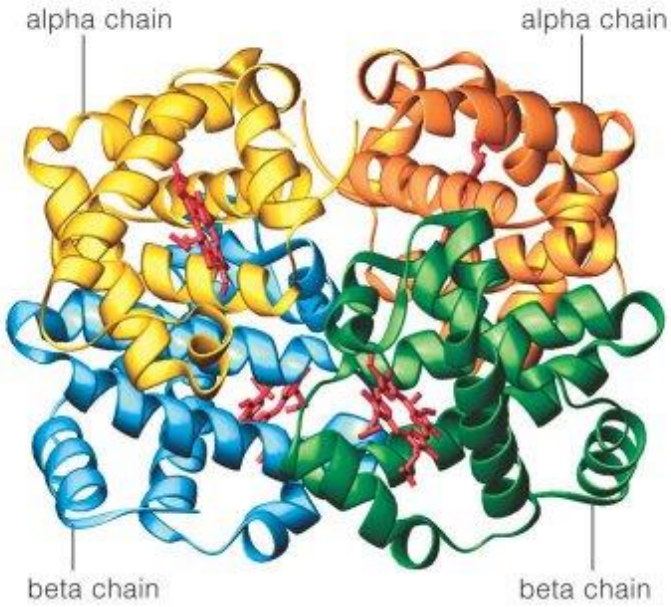
Primary structure → Tertiary structure

Proteins

Globular Protein – Haemoglobin

- Oxygen carrying pigment in RBC

- **Has quaternary structure**
- Made of 4 polypeptide chains
- 2 **α-globin** chains and 2 **β-globin** chains



- **Globular**
- Amino acids with non-polar / **hydrophobic R groups** are **inside**
- Amino acids with polar / **hydrophilic R groups** faces **outside**

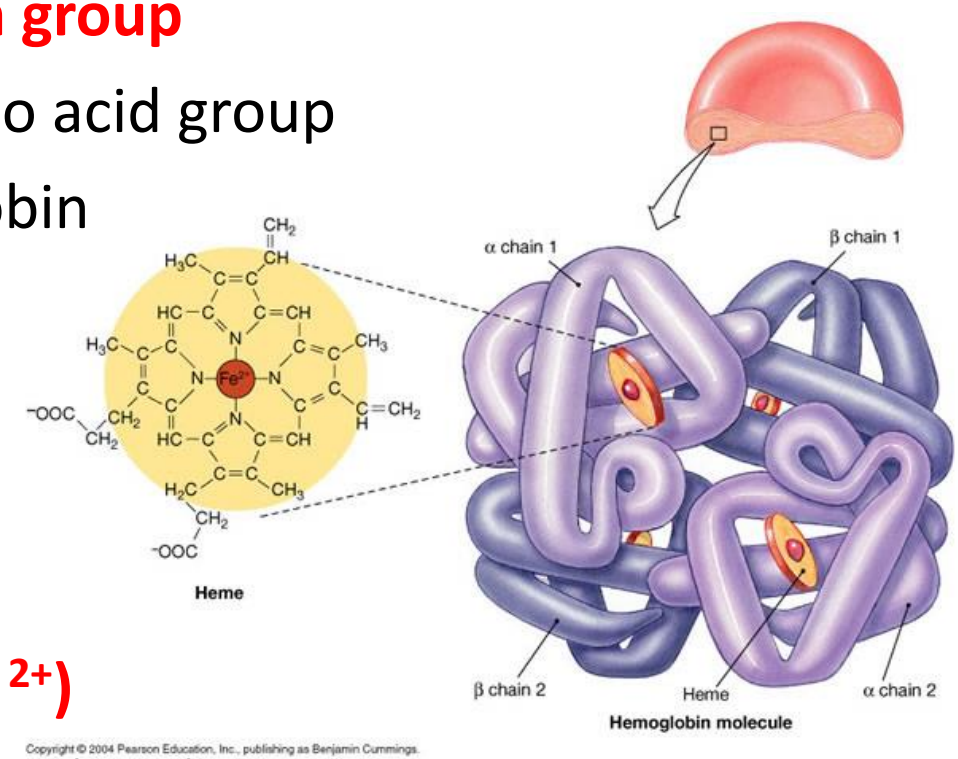
Proteins

Globular Protein – Haemoglobin

- Each polypeptide has a **haem group**

→ **Prosthetic group** = non-amino acid group

→ Permanent part of haemoglobin



- Each haem has 1 **iron ion (Fe^{2+})**

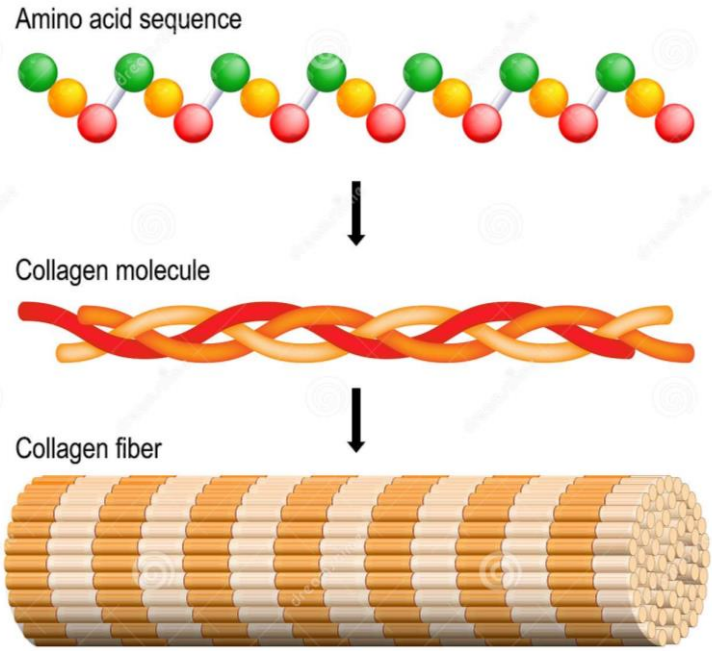
→ Each Fe^{2+} can bind 1 oxygen molecule

→ **One haemoglobin can bind 4 molecules of O_2**

Proteins

Fibrous Protein – Collagen

- Structural protein
- High tensile strength



- Every 3rd amino acid of each polypeptide is **glycine**
- Usually **pro**line-**ala**nine-**gly**cine repeat
- Glycine has the smallest R group!

→ so it can be tightly wound

- 3 polypeptide chains form **a triple helix collagen molecule**

→ Held by **hydrogen bonds**

→ **Quaternary structure**

Proteins

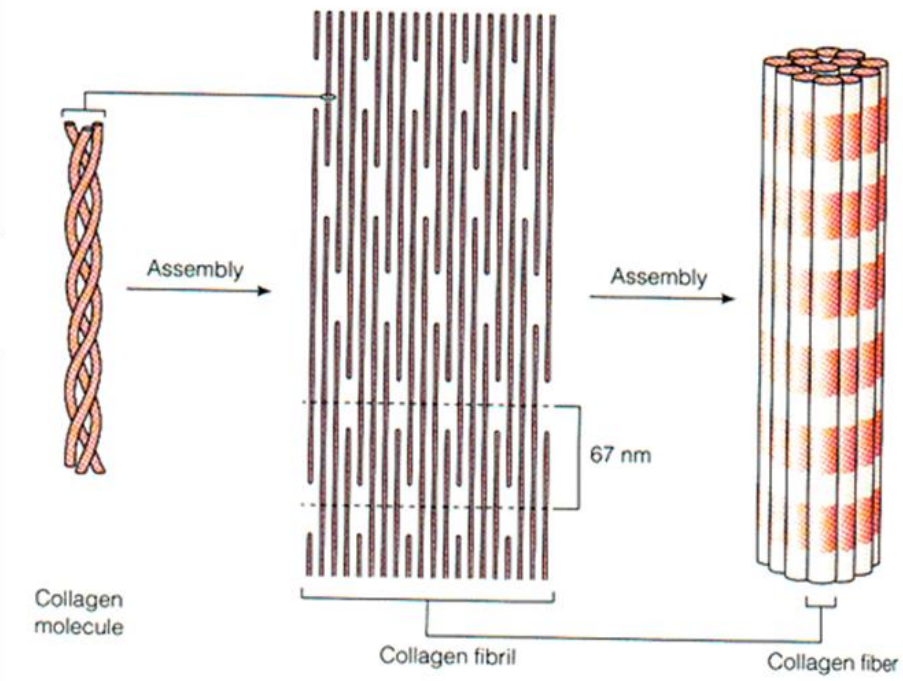
Fibrous Protein – Collagen

- **Collagen molecules** lie parallel
- And form **covalent cross-links**
- Between R groups of lysine a.a.

- **Staggered ends**

→ so no weak spot

- Forms fibrils and **fibres**



Polypeptide (mostly repeat of amino acids seq proline-alanine-glycine) → Triple-helical collagen molecule → Fibrils → Fibres

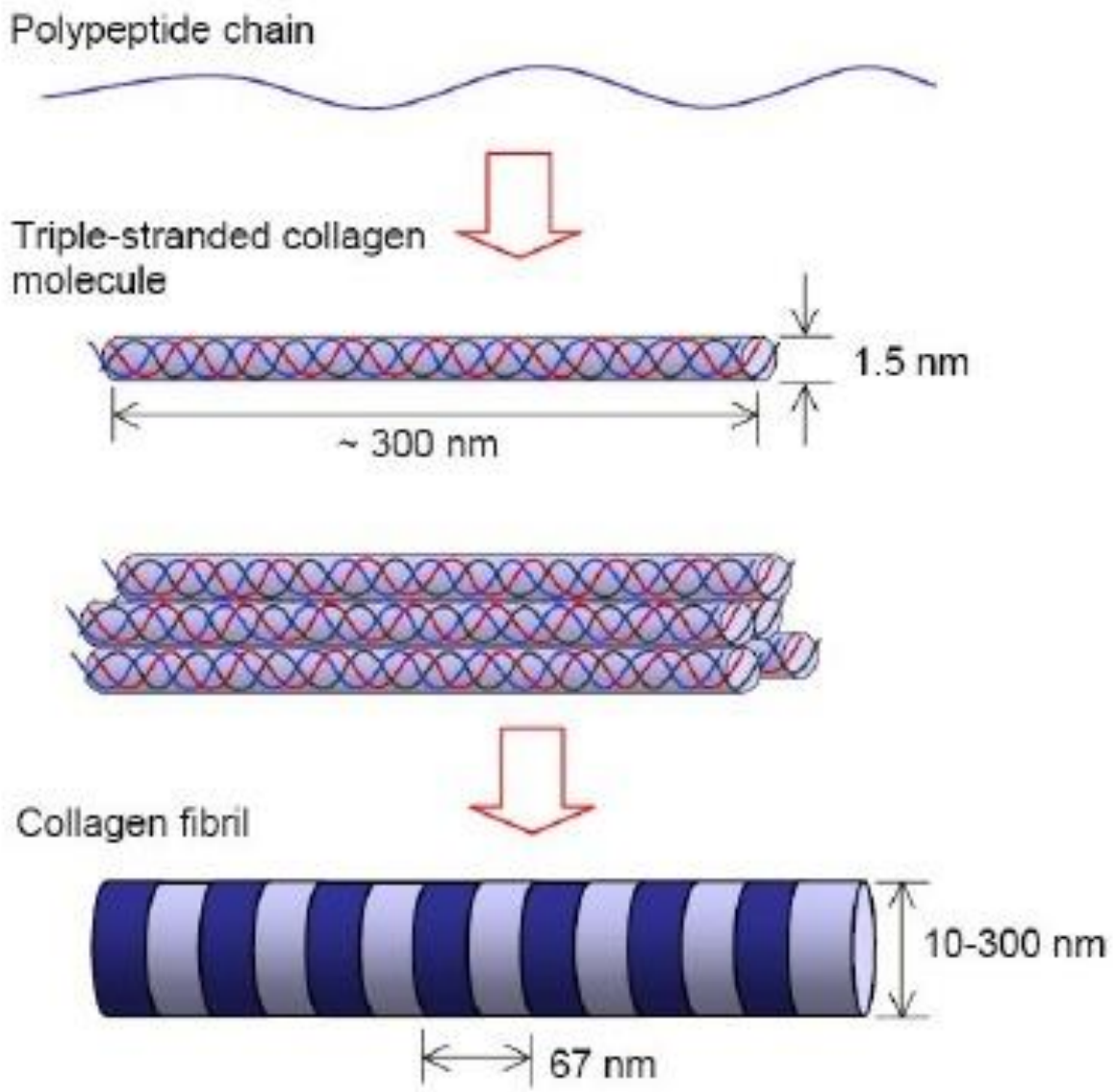
Proteins

Fibrous Protein – Collagen

Held together by:

H Bonds

Covalent cross-linkages

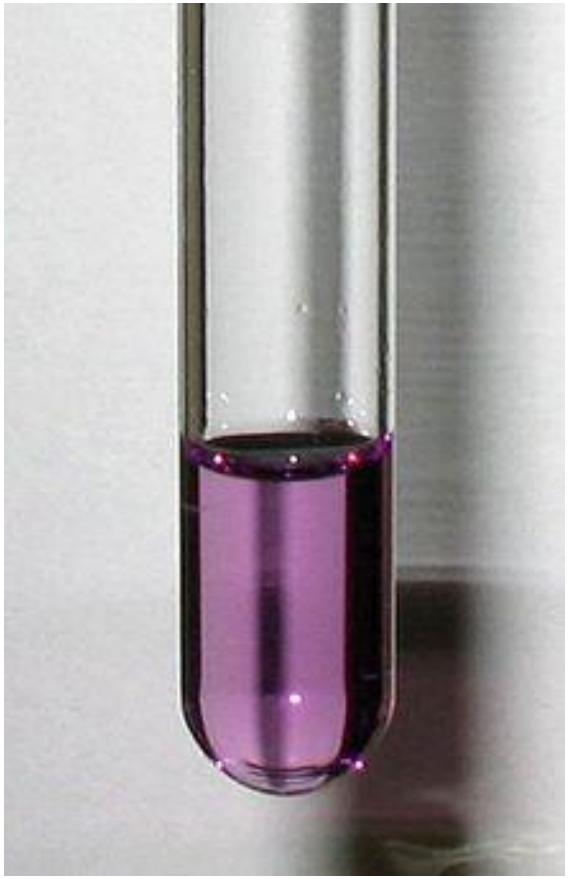


Testing the Presence of Proteins

- **Biuret reagent**
- Copper (II) sulphate and dilute potassium hydroxide
- Add $2cm^3$ of Biuret solution to $2cm^3$ of sample

- Purple – protein present
- Blue – no protein

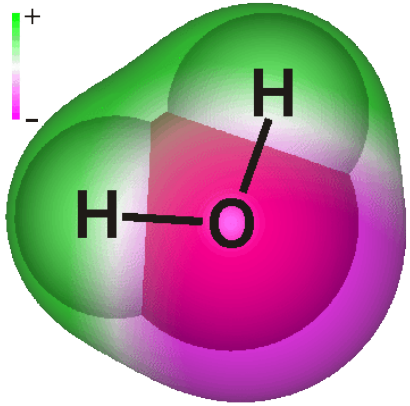
- NH_2 groups in amine react with copper ions → purple



WATER

Updated on 25/8/21 by Beh SJ @behlogy

Water



- **Dipole** in nature

→ O atom has slight negative charge

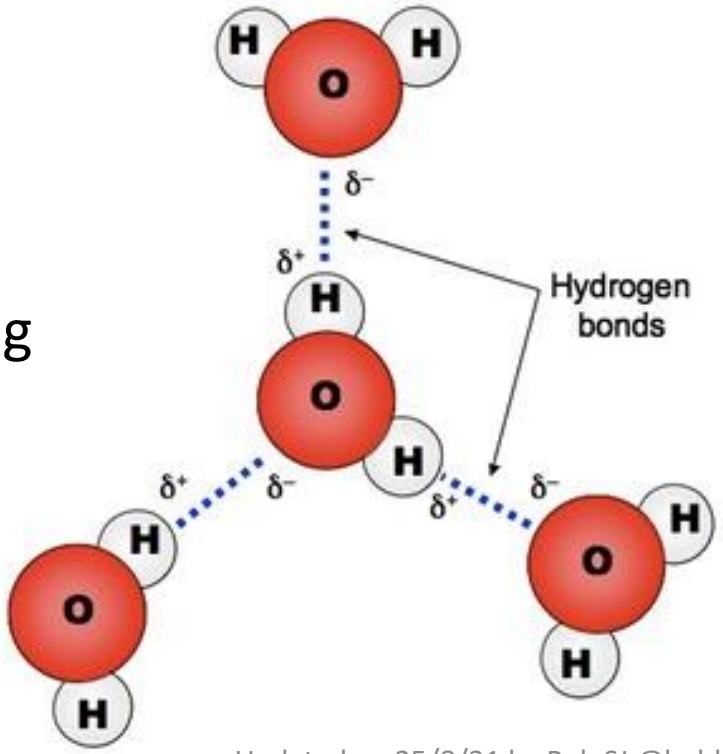
→ H atom has slight positive charge

- **Hydrogen bonding**

→ between O and H atoms of diff water molecules

→ individually weak, cumulatively strong

→ result in many properties of water

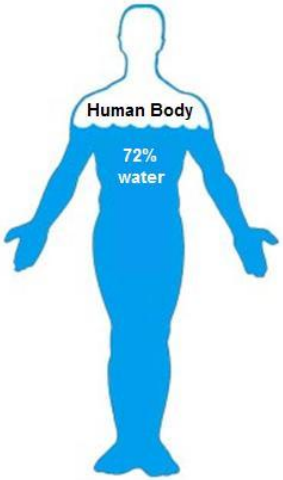


Water

Properties of Water

1) High specific heat capacity
2) High latent heat of vaporisation
3) High latent heat of fusion
4) Water as a solvent
5) Cohesion, Adhesion and Surface Tension

1) High specific heat capacity



- **Specific heat capacity** = amount of heat required to raise the temperature of 1 kg of water by 1^{o}C

- Large amount of energy needed to raise the temperature of water

→ Due to **H bonding** in water

→ Large energy needed to break H bonds

- **Provide stable temperature / environment**

→ Acts as buffer against sudden temperature change

→ Temperature of water does not change quickly

2) High latent heat of vapourisation

- **Latent heat of vapourisation** = amount of heat required to evaporate 1 g of water

- **Large amount of energy needed for water to evaporate**

→ Due to **H bonding** in water

- Able to **remove a large amount of heat** energy from surroundings

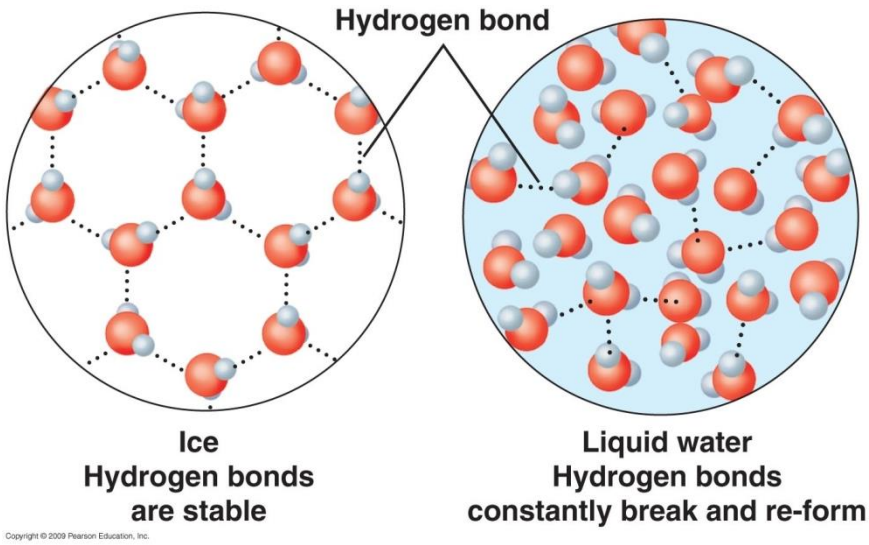
→ Important as a cooling mechanism

3) High latent heat of fusion

- Water also need **to lose a large amount of heat to freeze**

→ Due to H bonds

→ Provide stable habitats for aquatic organisms, less likely to freeze



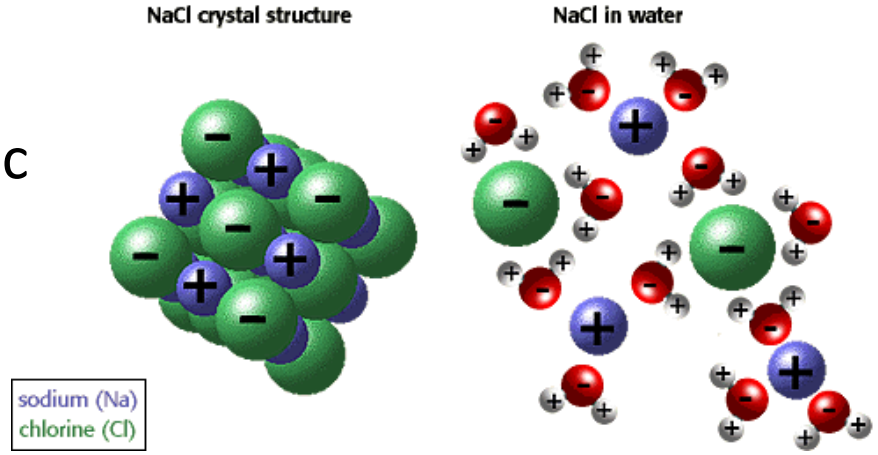
- **Ice is less dense than water**
- Water is most dense at 4°C
- Floats → acts as **insulator** on surface of frozen lakes

4) Water as Solvent

- Water is **dipolar**
- **Dissolves ions, polar molecules, gases** (oxygen, CO_2) and **waste products** (ammonia NH_3 and urea)

Important for:

- **Transport**, removal of wastes, secretions, medium for enzymatic reactions

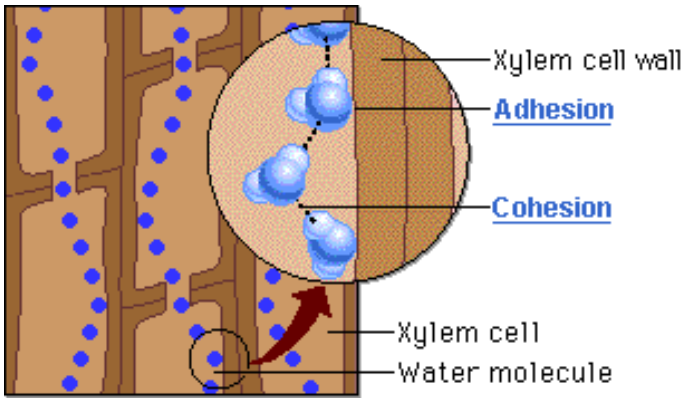


Not solvent for:

- Non-polar molecules (lipids)

5) Cohesion, Adhesion and Surface Tension

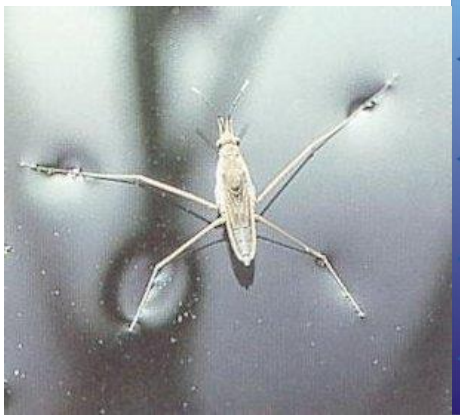
- Tend to stick to each other – **cohesion**
- Tend to stick to surfaces – **adhesion**
- Because of H bonds

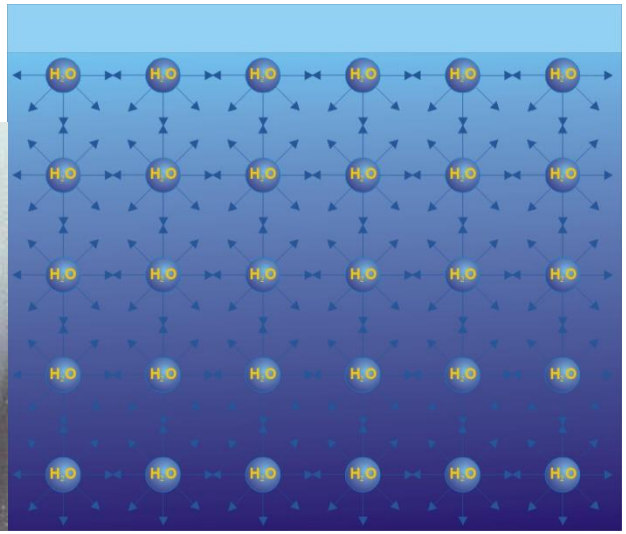


Useful for:

1) Transport of water in xylem tissue of plants

→ long, unbroken column of water





2) **High surface tension**

→ Surface dwellers' habitat

E.g. pond skater

Q: Describe the importance of water as an environment for fish at the North Pole. [4]

A:

1) Water is a solvent → provides (dissolved) oxygen and remove carbon dioxide / ammonia.

2) Water provides support / buoyancy

3) Water is liquid, so fish can move

4) Transparent, so fish can see

5) High specific heat capacity → so can provide stable temperature / environment

6) Ice less dense than water → ice floats and act as insulator, so can survive when water freezes

7) high latent heat of fusion, water does not freeze too easily

8) greatest density is at 4 °C → As a frozen lake warms after a cold winter, dissolved mineral nutrients are brought to the surface.

Chapter Outline

Monomer to Polymer
Hydrolysis and Condensation

Carbohydrates
- Monosaccharide, disaccharide and polysaccharide
- Glycosidic bond
- Starch (amylose and amylopectin)
- Glycogen
- Cellulose
- Benedict's Test / Iodine Test

Lipids
- Glycerol + 3 Fatty acids
- Ester bond
- Triglycerides
- Phospholipids
- Emulsion Test

Protein
- Amino acids
- Peptide bond
- Primary to quaternary structure
- Globular vs Fibrous proteins
- Haemoglobin
- Collagen
- Biuret Test

Water
- Hydrogen bond

Important Things to Remember

All tests
All bonds involved
Monomer and polymer names
Role of biomolecules
Examples of polymers – structure and function

P/S: Besides the **general structure of amino acids, glycine, alpha and beta glucose,** you don't need to know how to draw any chemical structures (from scratch anyway), but you need to be able to **recognise** them